Engineering Library
SEP 14 1917
UNIV. OF MICH. LIBRARY

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CIV.—No. 2692.] *LONDON: FRIDAY, AUGUST 3, 1917.* [*Registered at the General Post Office as a Newspaper.*] [PRICE 8d. BY INLAND POST 10d.

Aveling & Porter, Ltd.,
ROCHESTER, KENT.
and 72, CANNON STREET, LONDON.
STEAM ROLLERS. ROAD LOCOMOTIVES.
STRAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 6030

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, page 29.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2170

Cement.—Maxted & Knott, LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 3294

Cranes.—Electric, Steam,
HYDRAULIC and HAND.
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 5697

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 4457
See Advertisement last week, page 98.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9982

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD.,
ENGINEERS, NEWCASTLE-ON-TYNE. 5699

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON AND TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 5769

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS,
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, GLASGOW. Oct 8547
Registered Offices: 108a, Cannon St., London, E.C.

Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
155, HIGH HOLBORN, LONDON, W.C. 1.

Invincible Gauge Glasses.
BUTTERWORTH BROS. Ltd.,
Newton Heath Glass Works,
Manchester. Oct 9755

Iron and Steel
Tubes and Fittings.
6145
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 94, Robertson Street, Glasgow.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW (formerly of POPLAR, LONDON).
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
Exceptional Shallow Draught
VESSELS PROPELLED BY STEAM
Turbines or Oct 8752
Internal Combustion Engines.

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches, or Barges,
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Oct 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH

FOR
Sheet Metal Stampings or
write PRESSINGS
GARTSHERRIE ENGINEERING & FORGE CO.,
50, WELLINGTON STREET, GLASGOW. 5433

OIL FUEL APPLIANCES.
Systems
PRESSURE, AIR, STEAM.
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool; and
109, Fenchurch St., London.
Naval Outfits a Speciality.
4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Oct 2487
See their Illus. Advertisement, page 111, last week.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 100, July 27. 5734

Punch and Shear Machine
SPECIALISTS. 4784
Consult us. "The Best and the Cheapest." Large Stock. Satisfaction Guaranteed. Established 1860.
SCOTT BROS., WEST MOUNT, HALIFAX.

"Gripoly"
MACHINE BELTING
FOR
Driving
—
Conveying
—
Elevating
—
SOLE MANUFACTURERS
Lewis & Tylor, Ltd.,
CARDIFF. 5484
LONDON. MANCHESTER. GLASGOW.

Rubber Stamps, Stencils,
Steel Punches, Brands, Wages Boxes, Pay Checks, Automatic Numberers and Daters for Munition Factories, &c.
Stencil Ink, all Colours, in Stock. 6023
ASH RUBBER STAMP CO., LTD.,
19a, Constitution Hill, Birmingham.
Telephone—Central 788. Telegrams—"SIDASH."

John Bellamy, Limited,
MILLWALL, LONDON, E. 1916
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes, Iron and Steel.
Edwin Lewis & Sons, Ltd.,
Wolverhampton. 5628

Tubes and Fittings.
—
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 74. 6701

Rubber MANUFACTURERS
Packings "Redstone" "Bluestone"
GUTTA PERCHA & RUBBER, LIMITED,
Toronto - - Canada. 5018

New Chicago Automatics,
Three Sizes, Delivery from Stock.
NEW CAPSTANS, 1¼ in. through the wire feed.
JOHN MACNAB, MARY STREET, HYDE.
Tel. No.: 78 Hyde. 5109

THE WELL-KNOWN
Fine Red Moulding Sand,
FOR
IRON, BRASS, ALUMINIUM.
APPLY,
Mansfield Sand Co., Ltd.,
MANSFIELD, NOTTS. 5175

Generating Sets, Two 375 Kw., triple expansion engines, 440/550 volts D.C.
One 275 Kw. Willans-Westinghouse, A.C. three phase, 50 periods, 2200 volts.
GENERATOR, 200 Kw., compound, 500 volts.
A.C. MOTOR, 275 HP., 40 periods, three phase.
A.C. MOTOR, 120 HP., 40 periods, 440 volts, three phase, by Mavor & Coulson.
JENNINGS,
West Walls, Newcastle-on-Tyne. 6048

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY & TRAMWAY ROLLING STOCK,
Makers of WHEELS & AXLES, RAILWAY PLANT, FORGING, SMITH WORK, IRON AND BRASS CASTINGS.
Registered Office and Chief Works: Motherwell.
Cardiff Office: Gordon Chambers, 31, Queen Street.
London Office: 14, Leadenhall Street, E.C.
See Illustrated Advt. in alternate issues. Oct 3362

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices
WISHAW, near GLASGOW.
London Office:
2, VICTORIA STREET, WESTMINSTER, S.W. 6353

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS. 5824
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.
See half-page Advertisement, last and next week.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
STEAM AND GAS KETTLES.
Row's PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

Yarrow Patent
Water-tube Boilers. 4966
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Delta Metals. HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 5808
EAST GREENWICH, LONDON, S.E. (& at Birmingham)

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, Dumbarton. 6054
See Full Page Advt., page 68, June 29.

Forgings.
Walter Somers & Co., Ltd.,
HALESOWEN. 5549

Taylor & Challen
Presses.
6186

Railway
Switches and
Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 5440

RAILWAY CARRIAGES, ELECTRIC CARS, &c.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Oct 2363

Machine Tools in Stock:—Vertical DRILLS to admit 18 in., 26 in. and 36 in. diameter. Bolt Screwing MACHINES, 10½ in. centre Special Shafting LATHE. Second-hand PLANER, 25 ft. by 6 ft. by 6 ft.
JAMES SPENCER & CO., LTD., 4300
Chamber Iron Works, Hollinwood, Manchester.

Improved High Pressure
RENEWABLE DISC GLOBE VALVE.
See our Advertisement in last week's issue, page 30.
BRITISH STEAM SPECIALITIES, LTD.,
Bedford Street, Leicester. 2930

Machine and Engineering
WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

CHANTIERS & ATELIERS
Augustin - Normand
67, rue de Perrey—LE HAVRE
(France.)
3990
Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
5455
See half-page Advertisement page 78, July 13.

The Manchester Steam Users' Association.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. B. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5864

University of Birmingham.

Principal—Sir Oliver Lodge, M.Sc., D.Sc., LL.D., F.R.S.
Vice-Principal—Dr. R. S. Hiath, M.A.

ENGINEERING DEPARTMENTS.

I.—MECHANICAL ENGINEERING.

Chance Professor—F. W. Burstall, M.Sc., M.A. (Cantab.), M. Inst. C.E., M. Inst. M.E.
Lecturer—R. C. Porter, M.Sc. (Vict.), A.M. Inst. C.E.
Demonstrator—(Vacant).
Lecturer on Machine Design—F. J. Broscomb, M.Sc., A.M.I.M.E.
Assistant Lecturer on Machine Design—W. G. Wishart, B.Sc.

II.—CIVIL ENGINEERING.

Beale Professor—Frederick C. Lea, M.Sc., D.Sc. (Lond.), A.M.I.C.E., A.R.C.S.
Lecturer—W. Norman Thomas, M.Sc., A.M.I.C.E., A.M.I.M.E.
Assistant Lecturers and Demonstrators—Robert C. Panton, M.Sc., M.A., B.A.I., and P. M. Chadwick, M.Sc., A.C.G.I.

III.—ELECTRICAL ENGINEERING.

Professor—Gisbert Kapp, M.Sc., D.Eng., M. Inst. C.E., M. Inst. E.E.
Lecturers—E. J. Kipps, M.Sc., M. Inst. E.E., and Thomas F. Wall, D.Sc. (Manch.), D. Eng. (Lpool), A.M. Inst. C.E., A.M. Inst. E.E.
Assistant Lecturer and Demonstrator—(Vacant).

THE FULL COURSES EXTEND OVER FOUR YEARS, and Students who enter after Matriculation and pass successfully the Examinations at the end of each year WILL BE ENTITLED to the DEGREE of BACHELOR of SCIENCE in Engineering.

THE SESSION 1917-18 COMMENCES ON TUESDAY, 2nd OCTOBER, 1917.

For detailed Syllabus, with full particulars of University Regulations, Lecture and Laboratory Courses, Fees, Scholarships, &c, apply to the SECRETARY. H 289

The University of Sheffield.

SESSION 1917-1918.

Vice-Chancellor: W. Ripper, D.Eng., D.Sc., M.Inst.C.E., J.P.

DEPARTMENT OF APPLIED SCIENCE, COMPRISING FACULTIES OF ENGINEERING AND METALLURGY.

Professors in the Department.
Mechanical Engineering—W. Ripper, D. Eng., D.Sc., M.Inst.C.E.
Metallurgy—J. O. Arnold, D.Met., F.R.S.
Mining—F. H. Armstrong, M.Sc., A.M.Inst. C.E.
Applied Chemistry—L. T. O'Shea, M.Sc.
Mathematics—A. H. Leahy, M.A.
Physics—S. R. Milner, D.Sc. (Acting Prof.).
Chemistry—W. P. Wynne, D.Sc., F.R.S.
Geology—W. G. Fearnsides, M.A.

Electrical Engineering—H. H. Crapper, B.Eng., M.I.E.E. (Lecturer).
Civil Engineering—J. Husband, B.Eng., A.M.Inst. C.E. (Lecturer).
Glass Technology—W. H. S. Turner, D.Sc. (Lecturer).

The subjects in which Courses of study are provided include Engineering, Metallurgy, Coal Mining, Applied Chemistry, Mathematics, Physics, Chemistry, Geology and Glass Technology.

The DEPARTMENT OF ENGINEERING includes Courses in Civil, Mechanical, Electrical and Chemical Engineering, and Students specialise in one or other of these branches in the third year of their Course. The Course in Engineering extends over three years and prepares for the Degree of Bachelor of Engineering (B.Eng.) or for the Associateship of the University in Engineering. Special three years' Courses are arranged for Works' Pupils, who come to the University from Works in Sheffield or from other centres, taking six months' study at the University and six months' practice at the Works each year.

The DEPARTMENT OF METALLURGY includes (a) the Metallurgy of Iron and Steel, and (b) the Metallurgy of the Non-ferrous Metals. The Course in Metallurgy extends over three years, and prepares for the Degree of Bachelor of Metallurgy (B.Met.) or for the Associateship of the University in Metallurgy. The equipment of this department is on an exceptionally complete and practical scale.

The work of the DEPARTMENT OF COAL MINING includes a three or four years' Diploma Course, consisting of six months at the University and six months at a colliery.

The DEPARTMENT OF APPLIED CHEMISTRY deals specially with the subjects relating to various branches of Coal Mining, and of the Coal and Coke Industries.

The DEPARTMENT OF GLASS TECHNOLOGY provides (a) a Diploma Course requiring systematic study of the science and practice of Glass Manufacture, for a period of three years, and (b) Part Time and Special Courses.

The LECTURE COURSES of all the Departments are supplemented by Practical Training in Laboratories, Workshops and Foundries fully equipped for the purpose of advanced scientific teaching, investigation and research.

Part Time Courses are arranged for Students who desire to take special portions of any of the regular Courses.

The LECTURE COURSES commence 3rd October, 1917.

The TECHNICAL LABORATORY COURSES commence 24th September, 1917. H 114

W. M. GIBBONS, Registrar.

University of Manchester.

FACULTY OF SCIENCE.

DEPARTMENTS OF CIVIL, MECHANICAL AND ELECTRICAL ENGINEERING.

Full particulars of the Courses will be forwarded on application to the REGISTRAR.

The SESSION COMMENCES on the 4TH OCTOBER. H 435

South-Western Polytechnic

INSTITUTE, CHELSEA, S.W. 3.

UNIVERSITY and TECHNICAL DAY and EVENING COURSES in MECHANICAL and ELECTRICAL ENGINEERING commence 24th September, 1917.

Scholarship Examination, 17th September, Ten a.m.

Apprenticeship Scheme for Engineers.

Prospectus on application to the SECRETARY (Room 24).

Telephone: 809 Western. H 451

UNIVERSITY OF DURHAM.

Armstrong College,

NEWCASTLE-UPON-TYNE.

Principal—W. H. Hadow, M.A., D.Mus., J.P.

SESSION 1917-18.

COMMENCING 24th SEPTEMBER, 1917.

Departments of Mechanical, Marine, Civil and Electrical Engineering, Naval Architecture, Mining, Metallurgy, Agriculture, and of Pure Science, Arts and Commerce.

Full particulars may be obtained on application to—
F. H. Pruen, M.A., Secretary.
Armstrong College, Newcastle-upon-Tyne. 6156

Inst. C.E. and all Engineering

Examinations.—Mr. G. P. Knowles, B.Sc. Assoc.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes, including the Bayliss Prize. Courses for next February and October are just commencing.—39, Victoria St., Westminster, S.W. Tel. No. 1402, Victoria.

TENDERS.

MANCHESTER CORPORATION WATERWORKS.

The WATERWORKS COMMITTEE invite

Tenders for the Supply and

ERECTION of TWO ELECTRICALLY-DRIVEN TURBO-PUMPS with Automatic Control and Switch Gears, Pipes, Valves, &c.

Specification and Form of Tender can be obtained on application to the Secretary, Water Department, Town Hall, Manchester.

Tenders, endorsed "Tender for Turbo-Pumps, &c.," and addressed to the Chairman of the Waterworks Committee, to be forwarded not later than the 18th August, 1917.

By Order,
THOMAS HUDSON,
Town Clerk.

Town Hall, Manchester,
30th July, 1917. H 433

APPOINTMENTS OPEN.

CITY OF BIRMINGHAM.

ELECTRIC SUPPLY DEPARTMENT.

APPOINTMENT OF ASSISTANT CONSTRUCTIONAL ENGINEER.

An Assistant Constructional

ENGINEER is REQUIRED to assist in the preparation of specifications and plans for new buildings and lay-out of new steam and electrical plant, and in superintending the erection and testing of such plant.

He should be familiar with the latest practice as applied to large generating stations and should preferably have had workshop, central station and drawing office experience.

Forms of application, which may be obtained from the Secretary of the Electric Supply Department, 14, Dale End, Birmingham, must be filled in by the applicant, stating salary required, and accompanied by copies of not more than three testimonials as to experience, ability and character. These should be sent to the undersigned by August 25th, 1917.

R. A. CHATTOCK,
City Electrical Engineer.

14, Dale End,
Birmingham. H 439

COUNTY BOROUGH OF WEST HARTLEPOOL.

TECHNICAL COLLEGE.

Assistant Teacher (ineligible

for military service) REQUIRED in the Mechanical and Marine Engineering Department.

Laboratory workshop and teaching experience desirable.

Salary £130 per annum.

Further particulars may be obtained from the undersigned. Applications, together with two testimonials, to be sent in before the 15th August, 1917.

J. G. TAYLOR, Secretary.

Education Offices,
West Hartlepool. H 407

Engineers with Practical Ex-

perience of design of Ferro-Concrete Structures REQUIRED by MOUCHEL & PARTNERS, Ltd., 36, Victoria Street, Westminster, S.W. 1.—Apply by letter, stating age, experience and salary required. H 436

TYNE IMPROVEMENT COMMISSION.

DREDGING SUPERINTENDENT.

The Tyne Improvement Commission require the

Services of a Competent Per-

son to discharge the duties of DREDGING SUPERINTENDENT. Salary £300 per annum. Applications, stating age, present occupation and past experience, and accompanied by three recent testimonials, to be sent to the undersigned under cover, marked "Dredging Superintendent," not later than noon on Monday, the 6th August, 1917. The person appointed will be attached to the Engineer's Department, and his duties will include the superintendence of the whole of the dredging carried out by the Commissioners in the River Tyne and the movements of the river craft connected with the dredging work.

Further information as to the duties can be obtained on application.

Personal canvassing will be a disqualification.

By Order,
J. McDONALD MANSON,
General Manager and Secretary.

Tyne Improvement Commission Offices,
Newcastle-upon-Tyne.
24th July, 1917. H 428

CITY OF CARDIFF.

APPOINTMENT OF CITY ENGINEER AND SURVEYOR.

Applications are Invited for

this Appointment. Inclusive salary £1000 per annum. Particulars, conditions and duties may be obtained on application. Personal canvassing will disqualify, but each candidate shall send 50 prints of his application accompanied by copies of not more than three recent testimonials. Applications, stating age and experience and endorsed "City Engineer," to be delivered on or before 10th September, 1917.

J. L. WHEATLEY,
Town Clerk.

City Hall, Cardiff,
1st August, 1917. H 437

MUNICIPAL TECHNICAL SCHOOL, BLACKBURN.

Lecturer Required in

MECHANICAL ENGINEERING, to commence duties about 17th September, 1917.

Salary £160 to £200 per annum, according to qualifications and experience.

Applications should be sent before August 20th to the Principal, Dr. R. H. PICKARD, F.R.S., from whom further particulars may be obtained.

W. H. WHIPPLE, H 421
Director of Education.

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE
(Coleg Prifathrofaol Deheudir Cymru A Mynwy.)

Temporary Lecturer in

ENGINEERING REQUIRED. Salary at the rate of £200 per annum. Appointment and duties to commence on October 1st, 1917.

Candidates must hold a University Degree or its equivalent, and possess satisfactory qualifications for taking entire charge of all Courses in the Engineering Department for First-Year Students. Further particulars may be obtained from the undersigned,

D. J. A. BROWN,
Registrar.

University College,
Cathays Park, Cardiff.
July 30, 1917. H 447

Cost Accountant.—Wanted in

large Engineering Works in the Midlands, employing over 5000 hands, an expert COST ACCOUNTANT. To a thoroughly capable man, well versed in accounts and familiar with the latest costing methods, a permanent position is offered. Only those with practical experience in similar works need apply.—Address, stating age, experience and present employment, which particulars will be regarded as confidential, H 418, Offices of Engineering.

A Firm of Engineers and

Steel Founders can OFFER a good POST to really first-class business man with thorough knowledge of modern systems of works, sales and general office organization. Preference will be given to one with experience in the engineering or motor trade.—Write, stating qualifications and salary required, to BOX 5910, care of A. J. Wilson and Co., Ltd., 154, Clerkenwell Road, London, E.C. 1. H 369

Chief Engineer Required for

large Aero Engine Works, London district, 2000 hands employed. Salary, £1000 p.a.—Address, stating experience, H 343, Offices of Engineering.

Electrical Engineer.—Wanted,

Competent Electrical ENGINEER, able to take charge of the installation of generators, switchboard and all electrical appliances in large electric power station. Energetic men only need apply. Salary, £5. Must be ineligible for military service.—Address, H 350, Offices of Engineering.

Wanted, Shop Manager, with

practical experience on manufacture of Electrical Switchgear. Good possibilities for man with technical education and broad views regarding the handling of labour and efficient use of material. Give references, age and salary expected. No one employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 3504. H 444

First-class Experienced

ESTIMATOR WANTED by Government controlled works making large and small engines, repetition and general work; man with thorough practical knowledge of machining, fitting and foundries, &c., who could organise and control a department dealing with rate-fixing, progress and demonstration. Only men thoroughly experienced need apply. Permanent position to suitable man. State age, experience and salary required. No one already employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 30.

Works Manager, for Govern-

ment Controlled Establishment, with wide experience of small and accurate repetition work on a large scale; first-class knowledge of automatic and semi-automatic machine tools, methods of production, works' cost systems, tool room, and control of large numbers of male and female workers. Apply by letter, in first instance, stating fully age, experience and salary required. Liberal terms to first-class engineer with long experience of works management with the above qualifications. Works near London.—Sells's Advertising Offices, Fleet Street, E.C. 4. H 398

Works Manager.—A really

capable MAN, with sound engineering training and experience in works administration, is REQUIRED to take charge of a large aeroplane factory, London, N.W. Applicants need not necessarily have had previous experience in aeronautical engineering. No one engaged on Government work or resident more than 10 miles away need apply.—Write, stating salary required, to H 412, Offices of Engineering.

Wanted, First-class Engi-

NEERING CLERK of WORKS, competent to undertake control over the erection of all machinery, boilers, pipe-work, &c., for large electric power station. Must be competent to inspect and test plant, conversant with the latest engineering practice, methodical and energetic. Salary, £285 per year, with war bonus £15.—Address, H 348, Offices of Engineering.

Wanted, Assistant Engi-

NEERING CLERK of WORKS, well up in electric power station designs, competent to inspect and test plant; energetic man only need apply. Salary £5 per week. Must be ineligible for military service.—Address, H 349, Offices of Engineering.

Assistant Superintendent

WANTED in large engineering works, employed solely on direct Government contracts. The job is permanent and will continue after the war. A capable and energetic man experienced in repetition work will find ample opportunities for advancement.—Address, stating age, experience, and salary to H 342, Offices of Engineering.

Wanted, by Electrical En-

gineering Firm in Midlands on important Government work, YOUNG MAN of good education for commercial position in Purchasing Department. Previous experience not essential; preference given to one who has received technical engineering education. Young man discharged from army or navy, or unfit for service would suit. No person already employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 409.

Works Engineer, over Mili-

tary age, for a manufacturing concern in Lancashire (not engineering) employing about 900 hands. Duties consist of up-keep of all plant, machinery and buildings. Must have had similar experience, especially in building construction, as large extensions at present are taking place. No man at present employed on Government work will be engaged.—State age, full experience, together with salary required, accompanied by recent testimonials, to BOX "O 378," Lee & Nightingale, Liverpool. H 432

Assistant Engineer, experi-

enced in Blast Furnace and Steel Works Plant, WANTED for Steel Works in South Wales under Government control. Must be Six o'clock a.m. man. Ineligible for military service, and not already engaged on Government work.—Apply, stating age, qualifications, and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3439. H 293

Wanted, Foreman Engineer,

to take charge of all plant, such as compressors, steam boilers, electrical plant, &c., as is used at an Explosives Factory manufacturing Cordite and other explosives. No one at present engaged on Government work need apply.—State salary required and when at liberty, to BOX E.E. 20, care of Dawson's, 121, Cannon Street, E.C. 4. H 397

Wanted, a Good Practical

MAN as RATE FIXER in a large Crane Works, North of England. No person employed upon Government work will be engaged.—Apply, stating experience and salary, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 371.

Wanted, Engineer, Having

a thorough practical knowledge of gas producers, gas and coal-fired furnaces, competent to take charge of dressing office, estimate, draft specifications and conduct correspondence.—Apply, by letter, to G. P. Wincott, Ltd., Furnace Engineers, Sheffield. H 430

Experienced Accountant

CLERK WANTED. Ineligible and not already engaged on Government work. One having had experience in Engineering work preferred. Highest references essential. State age, experience and salary required to your nearest EMPLOYMENT EXCHANGE, quoting No. H 443.

Experienced Wages-Clerk,

also TIMEKEEPERS, WANTED for engineering works.—Apply, stating age, experience and wages required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3515. No person already on Government work will be engaged. H 450

Night Superintendent

WANTED, machine shop experience, for Engineering Works (on Government work) employing 700 hands. No person residing more than 10 miles away or already employed on Government work need apply.—Address, with full details, H 424, Offices of Engineering.

Smart Man, with Good Machine

Shop experience, as ASSISTANT WORKS MANAGER in Engineering Works (on Government work) employing 700 hands. No person residing more than 10 miles away or already employed on Government work need apply.—Address, with full details, H 425, Offices of Engineering.

STRESSES IN ROTATING DISCS WITH A HOLE AT THE CENTRE.

By W. KNIGHT.

THE object of the present paper is to give some relatively simple formulæ for the determination of stresses in rotating discs, either of uniform or of varying thickness, with a hole at the centre, produced by the centrifugal force of the disc only or by the centrifugal force of projecting masses attached at the periphery of the disc (as is the case with a turbine wheel with blades fitted at the periphery).

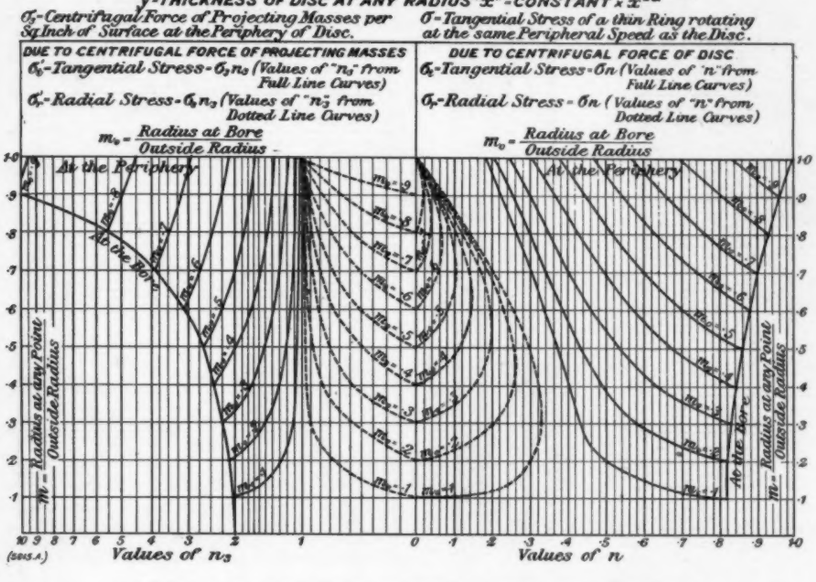


Fig. 1. DISC OF UNIFORM SECTION (α = 0) WITH A CENTRAL HOLE.
y = THICKNESS OF DISC AT ANY RADIUS "x" = CONSTANT × x^α
σ₀ = Centrifugal Force of Projecting Masses per Sq. Inch of Surface at the Periphery of Disc.
σ = Tangential Stress of a thin Ring rotating at the same Peripheral Speed as the Disc.
DUE TO CENTRIFUGAL FORCE OF PROJECTING MASSES
DUE TO CENTRIFUGAL FORCE OF DISC
σt = Tangential Stress = σ n₃ (Values of "n₃" from Full Line Curves)
σr = Radial Stress = σ n₃ (Values of "n₃" from Dotted Line Curves)
σt = Tangential Stress = σ n (Values of "n" from Full Line Curves)
σr = Radial Stress = σ n (Values of "n" from Dotted Line Curves)
m₀ = Radius at Bore / Outside Radius
At the Periphery
At the Bore
m = Radius at any Point / Outside Radius
Values of n₃
Values of n

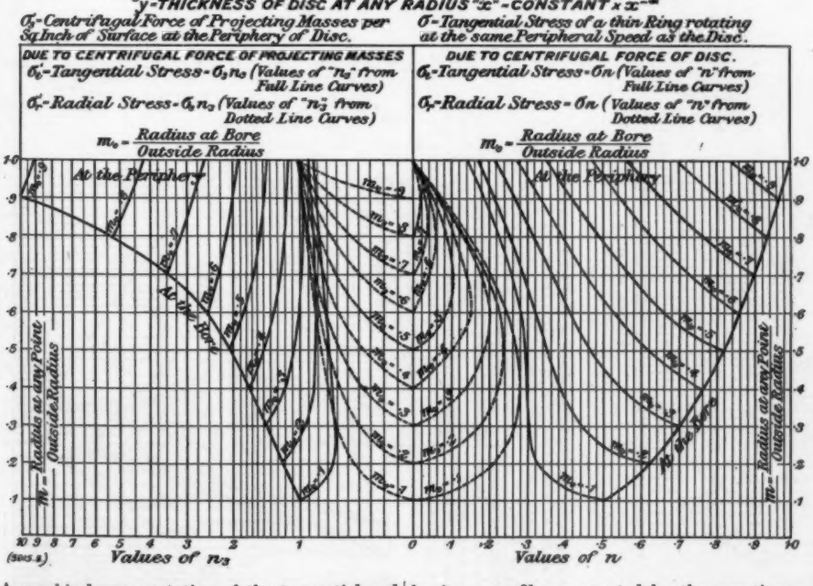


Fig. 2. DISC OF HYPERBOLIC SECTION (α = -½) WITH A CENTRAL HOLE.
y = THICKNESS OF DISC AT ANY RADIUS "x" = CONSTANT × x^α
σ₀ = Centrifugal Force of Projecting Masses per Sq. Inch of Surface at the Periphery of Disc.
σ = Tangential Stress of a thin Ring rotating at the same Peripheral Speed as the Disc.
DUE TO CENTRIFUGAL FORCE OF PROJECTING MASSES
DUE TO CENTRIFUGAL FORCE OF DISC.
σt = Tangential Stress = σ₀ n₃ (Values of "n₃" from Full Line Curves)
σr = Radial Stress = σ₀ n₃ (Values of "n₃" from Dotted Line Curves)
σt = Tangential Stress = σ n (Values of "n" from Full Line Curves)
σr = Radial Stress = σ n (Values of "n" from Dotted Line Curves)
m₀ = Radius at Bore / Outside Radius
At the Periphery
At the Bore
m = Radius at any Point / Outside Radius
Values of n₃
Values of n

A graphical representation of the tangential and radial stresses in straight discs and in discs of hyperbolic profile of the shapes most commonly used in practice is shown, and it is hoped that they will prove useful in doing away with the tedious process of solving the formulæ given and in readily picking out the proper shape of disc to be used for a given duty.

Several formulæ have been derived by different authorities for the determination of stresses in rotating discs of hyperbolic profile, and those published by Dr. Stodola in his book on "Steam Turbine" are well known to turbine designers.

Mr. H. M. Martin, in a book of recent publication on the "Design and Construction of Steam Turbines," has published some other formulæ and a plot of them for three shapes of discs.

The results obtained by using my formulæ are identical with those obtained by using Dr. Stodola's, and they agree also very closely with the results obtained by using Mr. Martin's formulæ. In order to facilitate the comparison I have followed the same scheme used by Mr. Martin in plotting some of my diagrams of stresses.

Discs of Hyperbolic Profile.—We will consider the case of a disc with a hole at the centre and having a profile represented by the equation:

$$y = \frac{c}{x^a}$$

Where y is the thickness of the disc at any radius x, c is a constant, and a may be either positive or negative or equal zero.

For $a = 0$ we have the case of a disc of uniform thickness.

For positive values of a we have the disc section used by de Laval for small wheels.

For negative values of a we have a profile of disc increasing in thickness from the bore toward the periphery.

The exponent a is given by:

$$a = \frac{\log \frac{y_1}{y_2}}{\log \frac{x_2}{x_1}}$$

Where y_1 and y_2 are the thicknesses of the disc at the corresponding radii x_1 and x_2.

The following symbols will be used:—

σ_t, σ_r = tangential and radial stresses at any radius due to the centrifugal forces of the disc only.

σ_t^1, σ_r^1 = tangential and radial stresses at any radius due to the centrifugal force of the projecting masses only.

σ = tangential stress in a thin ring of the same materia as the disc, and rotating at a speed equal to the peripheral speed of the disc.

m = ratio of radius at any point to the outside radius.

m_0 = ratio of radius at the bore to the outside radius.

$$\psi_1 = \frac{a}{2} + \sqrt{\frac{a^2}{4} + a v + 1}$$

$$\psi_2 = \frac{a}{2} - \sqrt{\frac{a^2}{4} + a v + 1}$$

v = Poisson's ratio. (for steel $v = 0.3$)

$A = (2 - v^2)(1 - v^2) B$; for $v = 0.3$ $A = 1.74 B$

$B = \frac{2 - v^2}{8 - (3 + v) a}$; for $v = 0.3$ $B = \frac{1.91}{8 - 3.3 a}$

$C = -(2 - v^2)(1 - v^2)\psi_2$; for $v = 0.3$ $C = -1.74 \psi_2$

$D = (2 - v^2)(1 - v^2)\psi_1$; for $v = 0.3$ $D = 1.74 \psi_1$

$$\sigma_2 = \sigma \left\{ A \left[-m^2 + \frac{m^{\psi_1 - \psi_2}\left(m_0^{3 - \psi_2} - 1\right) - \left(m_0^{3 - \psi_2} - m_0^{\psi_1 - \psi_2}\right)}{m^{1 - \psi_2}\left(m_0^{\psi_1 - \psi_2} - 1\right)} \right] \right\}$$

$= \sigma n$ (values of n from dotted-line curves).

$$\sigma_t = \sigma \left\{ B \left[-m^2 + \frac{C\, m^{\psi_1 - \psi_2}\left(m_0^{3 - \psi_2} - 1\right) + D\left(m_0^{3 - \psi_2} - m_0^{\psi_1 - \psi_2}\right)}{m^{1 - \psi_2}\left(m_0^{\psi_1 - \psi_2} - 1\right)} \right] \right\}$$

$= \sigma n$ (values of n from full-line curves).

$$\sigma^1{}_r = \sigma_3 \frac{m_0^{\psi_1 - \psi_2} - m^{\psi_1 - \psi_2}}{m^{1 - \psi_2}\left(m_0^{\psi_1 - \psi_2}\right)}$$

$= \sigma_3 n_3$ (values of n_3 from dotted-line curves).

$$\sigma^1{}_t = \sigma_3 \frac{\psi_1 m_0^{\psi_1 - \psi_2} - \psi_2 m^{\psi_1 - \psi_2}}{m^{1 - \psi_2}\left(1 - m_0^{\psi_1 - \psi_2}\right)}$$

$= \sigma_3 n_3$ (values of n_3 from full-line curves).

By putting $m = m_0$ in the above formulæ we obtain the stresses at the bore, and by putting $m = 1$ we obtain the stresses at the periphery of the disc for any value of m_0.

From Figs. 1 to 5 the radial and tangential stresses at any point between the bore and the periphery of the disc can be obtained for values of m_0 between $m_0 = 0.1$ and $m_0 = 1.0$, and for values of a equal 0, 0.5, 1.0, 1.5, 2.0. The right-hand side of the diagrams gives a set of values of n which, multiplied by σ, give the tangential stresses (values of n from full-line curves) produced by the centrifugal force of the disc only, and a set of values of n (from dotted-line curves) which, multiplied by σ, give the radial stresses produced by the centrifugal forces of the disc only. On the left-hand side of the diagrams two sets of values of n_3 (full-line and dotted-line curves), multiplied by σ_3, give the tangential and radial stresses, respectively, produced by the centrifugal forces of the projecting masses only.

From Fig. 6 values of n and n_3 for stresses at the bore can be obtained (from full-line curves), and for stresses at the periphery (from dotted-line curves) for any value of m_0 between $m_0 = 0.1$ and $m_0 = 1.0$, and for values of a between $a = 0$ and $a = 2.0$.

From Fig. 7 values of n and n_3 for tangential stresses only at any point between the bore and the periphery can be obtained for any value of a, between $a = 0$ and $a = 2.0$.

These seven plots, of which every point has been carefully calculated, will give, it is hoped, a very clear idea of the distribution of the stresses in a disc of a given shape and of given proportions.

In the case of a turbine wheel we have a hub and rim which will change the theoretical hyperbolic

STRESSES IN ROTATING DISCS WITH A HOLE AT THE CENTRE.

Fig. 3. DISC OF HYPERBOLIC SECTION ($\alpha = 1$) WITH A CENTRAL HOLE.
y = THICKNESS OF DISC AT ANY RADIUS "x" = CONSTANT × x^{-m}

σ_r = Centrifugal Force of Projecting Masses per Sq. Inch of Surface at the Periphery of Disc. σ = Tangential Stress of a thin Ring rotating at the same Peripheral Speed as the Disc.

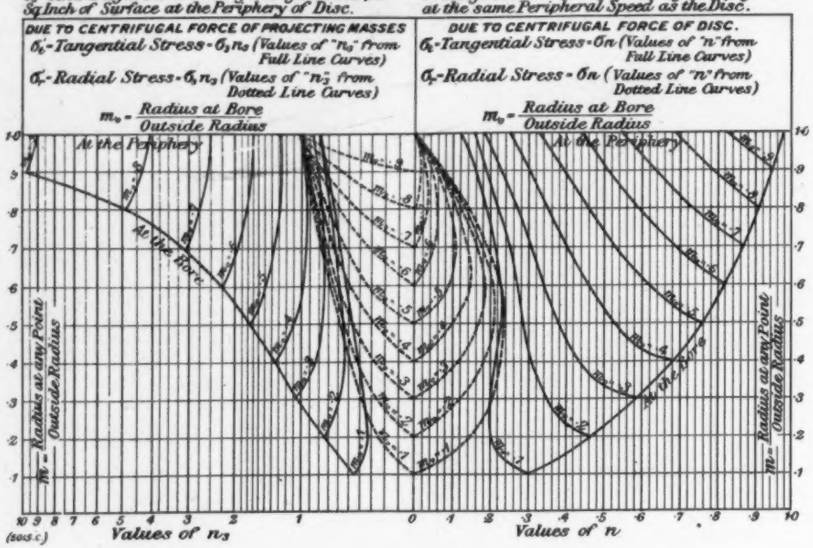

DUE TO CENTRIFUGAL FORCE OF PROJECTING MASSES
σ_t = Tangential Stress = $\sigma_3 n_3$ (Values of "n_3" from Full Line Curves)
σ_r = Radial Stress = $\sigma_3 n_3$ (Values of "n_3" from Dotted Line Curves)
m_0 = Radius at Bore / Outside Radius
DUE TO CENTRIFUGAL FORCE OF DISC.
σ_t = Tangential Stress = σn (Values of "n" from Full Line Curves)
σ_r = Radius at Bore / Outside Radius
At the Periphery
At the Bore
m = Radius at any Point / Outside Radius
Values of n_3
Values of n

Fig. 4. DISC OF HYPERBOLIC SECTION ($\alpha = 1.5$) WITH A CENTRAL HOLE.
y = THICKNESS OF DISC AT ANY RADIUS "x" = CONSTANT × x^{-m}

σ_r = Centrifugal Force of Projecting Masses per Sq. Inch of Surface at the Periphery of Disc. σ = Tangential Stress of a thin Ring rotating at the same Peripheral Speed as the Disc.

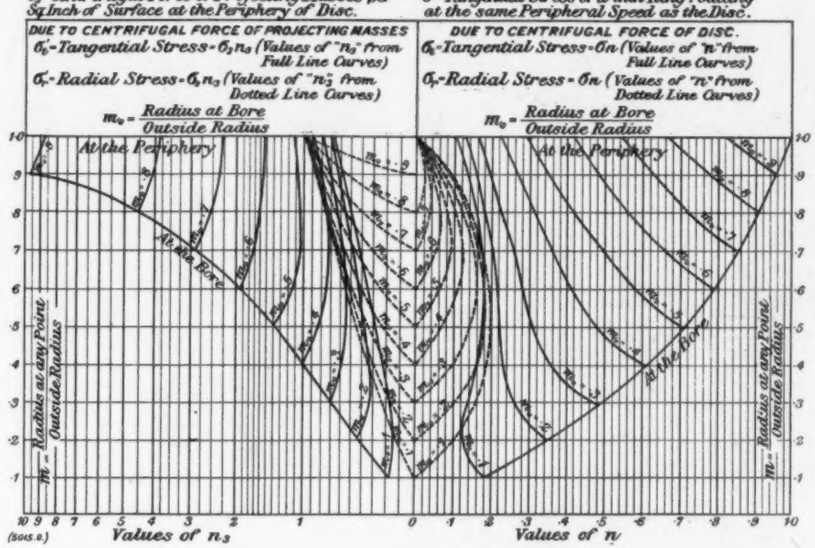

DUE TO CENTRIFUGAL FORCE OF PROJECTING MASSES
σ_t = Tangential Stress = $\sigma_3 n_3$ (Values of "n_3" from Full Line Curves)
σ_r = Radial Stress = $\sigma_3 n_3$ (Values of "n_3" from Dotted Line Curves)
m_0 = Radius at Bore / Outside Radius
DUE TO CENTRIFUGAL FORCE OF DISC.
σ_t = Tangential Stress = σn (Values of "n" from Full Line Curves)
σ_r = Radial Stress = σn (Values of "n" from Dotted Line Curves)
m_0 = Radius at Bore / Outside Radius
At the Periphery
At the Bore
m = Radius at any Point / Outside Radius
Values of n_3
Values of n

Fig. 5. DISC OF HYPERBOLIC SECTION ($\alpha = 2$) WITH A CENTRAL HOLE.
y = THICKNESS OF DISC AT ANY RADIUS "x" = CONSTANT × x^{-m}

σ_r = Centrifugal Force of Projecting Masses per Sq. Inch of Surface at the Periphery of Disc. σ = Tangential Stress of a thin Ring rotating at the same Peripheral Speed as the Disc.

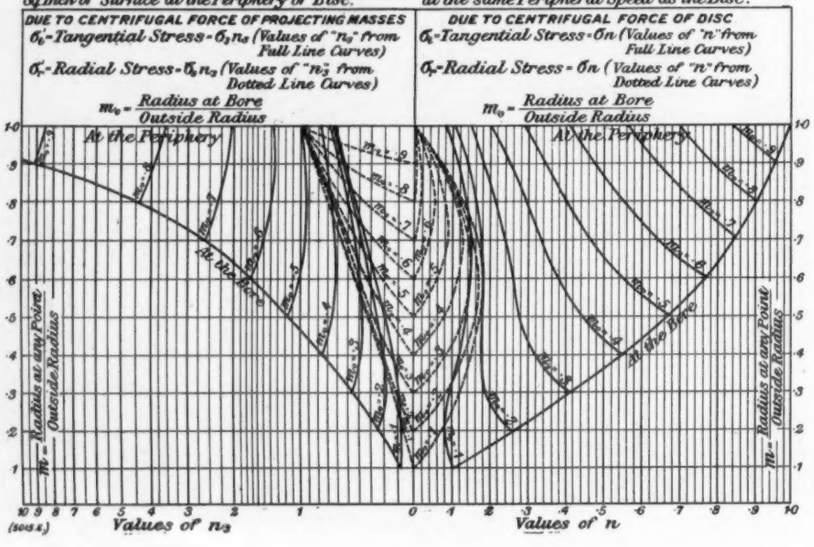
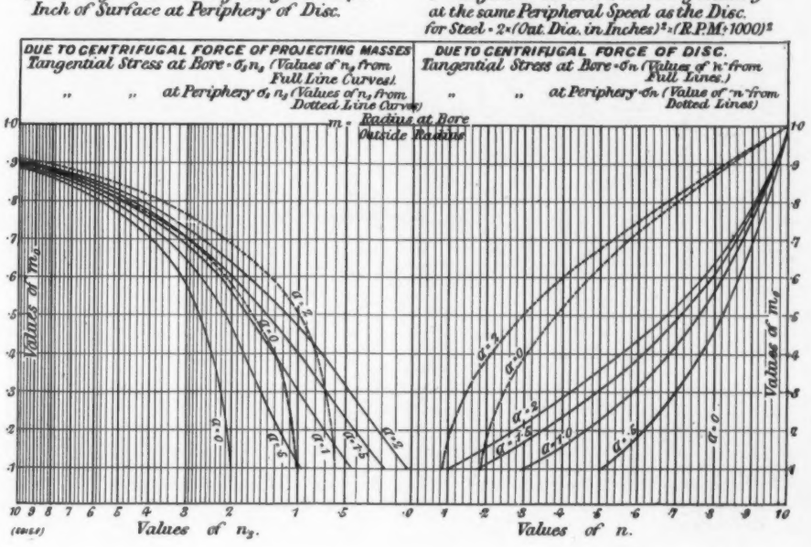

DUE TO CENTRIFUGAL FORCE OF PROJECTING MASSES
σ_t = Tangential Stress = $\sigma_3 n_3$ (Values of "n_3" from Full Line Curves)
σ_r = Radial Stress = $\sigma_3 n_3$ (Values of "n_3" from Dotted Line Curves)
m_0 = Radius at Bore / Outside Radius
DUE TO CENTRIFUGAL FORCE OF DISC
σ_t = Tangential Stress = σn (Values of "n" from Full Line Curves)
σ_r = Radial Stress = σn (Values of "n" from Dotted Line Curves)
m_0 = Radius at Bore / Outside Radius
At the Periphery
At the Bore
m = Radius at any Point / Outside Radius
Values of n_3
Values of n

Fig. 6. DISC OF HYPERBOLIC SECTION, THICKNESS AT ANY RADIUS "x^m" = CONSTANT x^{-m}.

σ_r = Centrifugal Force of Projecting Masses per Inch of Surface at Periphery of Disc. σ = Tangential Stress of a thin Ring rotating at the same Peripheral Speed as the Disc. for Steel = $2 \times (\text{Dia. in Inches})^2 \times (\text{R.P.M.} \div 1000)^2$


DUE TO CENTRIFUGAL FORCE OF PROJECTING MASSES
Tangential Stress at Bore = $\sigma_3 n_3$ (Values of n_3 from Full Line Curves)
" " at Periphery $\sigma_r n_3$ (Values of n_3 from Dotted Line Curves)
DUE TO CENTRIFUGAL FORCE OF DISC.
Tangential Stress at Bore = σn (Values of "n" from Full Lines.)
" " at Periphery = σn (Value of "n" from Dotted Lines)
m = Radius at Bore / Outside Radius
Values of n_3
Values of n.

STRESSES IN ROTATING DISCS WITH A HOLE AT THE CENTRE.

DISC OF HYPERBOLIC SECTION ($y = \text{THICKNESS AT ANY RADIUS } x = \text{CONSTANT}. x^n = y$).

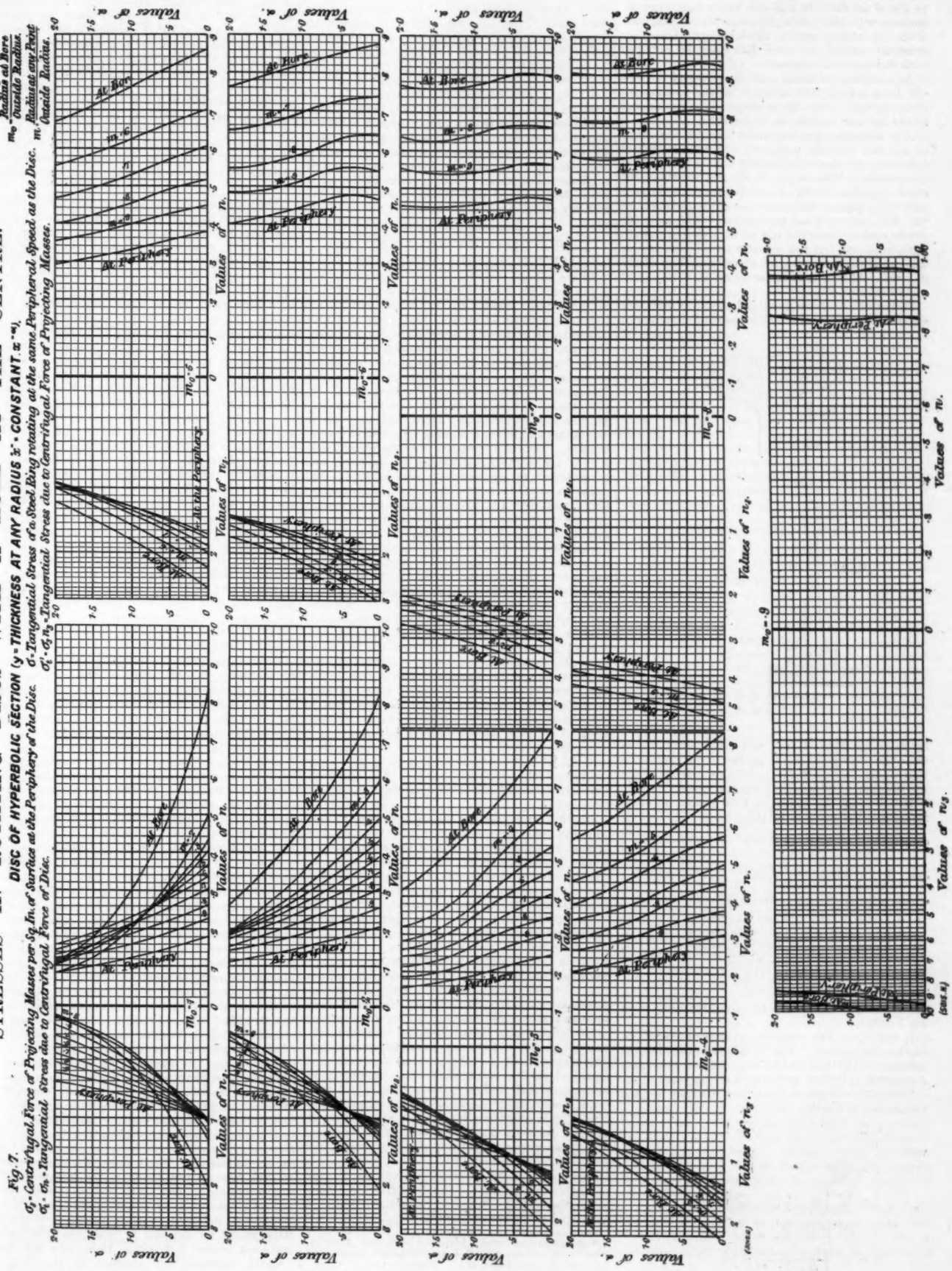


Fig. 7.

σ_1 - Centrifugal Force of Projecting Masses per Sq. In. of Surface at the Periphery of the Disc.
σ_2 - σ_3 - Tangential Stress due to Centrifugal Force of Disc.
σ - Tangential Stress of a Steel Ring rotating at the same Peripheral Speed as the Disc.
$\sigma_1 \cdot \sigma_2 n_2$ - Tangential Stress due to Centrifugal Force of Projecting Masses.

m_0 = Radius at Bore / Outside Radius.
m = Radius at any Point / Outside Radius.

profile of the disc. In this case some rough approximations will still allow the use of the diagrams given, obtaining results close enough, for every practical purpose, to those that could be obtained with elaborate calculations.

Any addition of metal near the centre of the disc will have a negligible influence on the distribution of the stresses, and so the influence of the extra metal at the hub can be left out of account.

Any addition of metal which changes the shape of the disc near the periphery will have a decided influence on the distribution and magnitude of the stresses. The weight of the rim shown in the shaded portion of Fig. 8 could be considered as a projecting mass of metal carried at the periphery of the disc, but such an assumption would be a too severe one, because the rim is, to a certain extent, self-supporting. If we consider two-thirds only of that weight as being carried at the periphery of the disc we will have, in the average cases, a very good approximation.

In general, a little good judgment in reducing general cases to the particular cases of discs shown

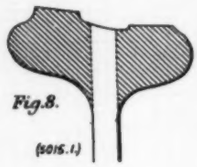


Fig.8.

(SOLID.)

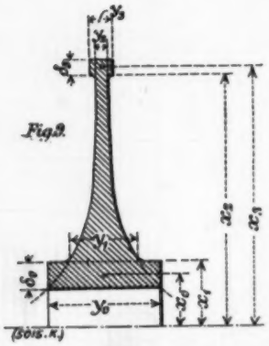


Fig.9.

(SOLID.)

in diagrams, Figs. 1 to 7 will yield better results than the large amount of mathematical operations that would be required for a definite analysis of the distribution of stresses in a turbine wheel.

Dr. Stodola has given us two general formulæ for calculating stress in rotating discs:

$$\sigma_r = \frac{E}{1-v^2}\left[(3+v)kx^2+(\psi_1+v)b_1x^{\psi_1-1}+(\psi_2+v)b_2x^{\psi_2-1}\right]$$

$$\sigma_t = \frac{E}{1-v^2}\left[(1+3v)kx^2+(1+\psi_1 v)b_1x^{\psi_1-1}+(1+\psi_2 v)b_2x^{\psi_2-1}\right]$$

where, with the inch-lb.-second system:

ω = Angular velocity in radians per second.
μ = Unit of mass of metal of disc (steel = 000,725).
E = Modulus of elasticity (steel = 30,000,000).

$$k = \frac{-(1-v^2)\mu\omega^2}{E[8-(3+v)a]}$$

x = Radius at any point in inches.

All other symbols having the same meaning as in my formulæ.

b_1 and b_2 are two constants of integration which, in the case shown in Fig. 9, take into account the influence of the rim, the hub and a force fit producing a pressure σ_0 lb. per square inch at the bore.

These two constants have been derived for the case shown in Fig. 9:

$$b_1 = \frac{p(e+f)-h(m+n)}{gp-oh}; \quad b_2 = \frac{m+n-b_1 o}{p}$$

where:

$$e = \frac{x_0^2\sigma_0}{E\delta_0}$$

$$f = \frac{\mu\omega^2}{E}\left[x_0^3+\frac{x_0^3}{2.43-a}\left(\frac{x_0 y_0}{\delta_0 y_0}+0.276\right)\right]$$

$$g = x_0^{\psi_1}\left[\frac{x_0 y_1(\psi_1+v)}{\delta_0 y_0(1-v^2)}+1\right]$$

$$h = x_0^{\psi_2}\left[\frac{x_0 y_2(\psi_2+v)}{\delta_0 y_0(1-v^2)}+1\right]$$

$$m = \frac{x_0^2\sigma_0}{E\delta_0}$$

$$n = \frac{\mu\omega^2}{E}\left[x_0^3-\frac{x_1^3}{2.43-a}\left(\frac{x_0 y_1}{\delta_0 y_0}+0.276\right)\right]$$

$$o = x_1^{\psi_1}\left[1-\frac{x_0 y_1(\psi_1+v)}{\delta_0 y_0(1-v^2)}\right]$$

$$p = x_1^{\psi_2}\left[1-\frac{x_0 y_1(\psi_2+v)}{\delta_0 y_0(1-v)}\right]$$

The complicated form of Dr. Stodola's equations suggested to me the idea of simplifying and expressing them in such a form as to allow a graphical representation of them which would entirely eliminate the chance of making errors in the calculation, and I hope that I have succeeded in this with my diagrams from No. 1 to 7.

INDUSTRIAL COUNCILS AND THE GARTON MEMORANDUM.—No. I.

As we pointed out recently, the recommendations of the Joint Standing Industrial Councils contained in the interim report of the Sub-Committee on Relations between Employers and Employed were in substance proposed in the Garton Memorandum, and the two schemes are so similar that there can be no doubt that the present proposals are due to the same influences as inspired those of the earlier document. Where, however, the committee's report consists of 6 pages, the Memorandum* runs into 96, and is correspondingly more explicit, both in its scheme and in the reasoning by which it is commended. The subject-matter is at the present time of such far-reaching importance to industry, and in particular to engineering manufactures, that engineers would be well advised to make themselves acquainted with the foundations of the proposals that are before them. They have nowhere received clearer or more forcible expression than in the Garton Memorandum, which is an able, lucid, and interesting document, written with unusual authority and grace. It purports to be the result of the round-table deliberations of persons "of very varied views, in touch with both the capitalist and employer classes and organised labour, as well as with financial, economic, and administrative circles"; and many who have not the leisure to study the voluminous original may care to consider the summary of its argument that is here given. The Memorandum includes many more subjects than the relations of Capital and Labour; but in order to exhibit fairly and without colour both the whole of its scope and the relative importance that the authors attach to the several parts of their material, it has been thought best to give some account of the entire document. The summary therefore enumerates its principal contents without comment.

(*a*) *The Impending Crisis.*—Through mutual suspicion and absence of sympathy Capital and Labour have failed to recognise the essential community of their interests. Their present union for specific war purposes is only temporary, and when those purposes have been attained will be ended abruptly unless the true relations between the various parties to industry have been made plain and embodied in a concrete policy. "Many of the men who return from the trenches to the great munition and shipbuilding centres are within a few weeks of their return among those who exhibit most actively their discontent with the present conditions. . . . So long as the peril from without remains the supreme factor, we may look to the workman to forego his most cherished safeguards"; but "the very moderation and unselfishness shown by the responsible leaders of organised labour are looked upon by important sections of their following as a betrayal of their cause, and by some employers as a tactical opportunity." Production after the war will tend to be lessened through death, disablement and emigration, deterioration of national plant, overwork, and arrest of industrial education; and though other causes may tend to determine an increase, the net production on pre-war methods will be less than before the war and will long remain so "unless it can be rendered more efficient." The national income from foreign investments and financial services will for years be much below the pre-war level; and with reduced production and increased debt, and the dear capital and scarce credit which the text of the Memorandum gives reasons for expecting, the earnings of industry as a whole at the beginning of peace will fall. Indeed, the enormous amount that will be payable to investors as interest on the National Debt may conceivably give rise to a demand for repudiation, which can best be prevented by encouraging wage-earners to invest their savings in Government bonds, and causing taxation to fall mainly on the creditor classes.

The reduction of their joint income will naturally sharpen the quarrel between Capital and Labour over its distribution, all the more because high prices and vanished separation allowances will contrast with the recollection of high war wages and the good military standard of maintenance; though the amount of war wages has not been due to a high rate, but in almost all cases has been earned by unsparing labour on piecework or by working long hours overtime. The bitterness that will be felt will be intensified through the fate of trade union restrictions and dilution of labour. "Pledges have been given for the restoration of the *status quo*," but "it will be very much more difficult than was expected to fulfil these pledges literally. . . . Any hitch in the restoration of trade-union safeguards" will powerfully reinforce the belief that advantage is being taken of the war to prejudice the position of labour. Feelings will be further embittered by various grievances and suspicions. On the one side it will be feared that returned soldiers may be used as "black-leg" labour, and that compulsory military service may be used as a permanent means of strike-breaking and neutralising the power of organised labour. On the other side there will be influences such as the memory of war-time strikes. These forces of discontent will be assisted by the natural reaction from the patience with which war needs were faced, especially when the burdens of permanent sacrifice are left to be borne throughout the nation in shares that often must be desperately unequal.

Incendiaries are to be found in all classes; and, unreasonable though much of this recrimination may be, it supplies material with which such persons may persuade a large following into industrial warfare, and the more readily because "the war has habituated men to the idea of conflict as a means of settling disputes." A similar danger may arise from reactionary employers who, remembering that even the supreme appeal of the war has failed to prevent strikes, "extortionate wage-demands, broken time, slackness, insubordination, and sullen resistance to temporary changes, the necessity for which has been openly acknowledged," may see in war conditions the chance of establishing the ascendancy of Capital over Labour once for all, and creating an industrial Prussianism.

(*b*) *The Memorandum's Programmes.*—The urgent emergency problem is, therefore, "simply to avert an outbreak of industrial anarchy," which there is otherwise every reason to expect at the end of the war. If it occurred, it would not improbably "be ended by hasty and ill-considered State action, placing industry as a whole under the yoke of a bureaucratic tyranny"; and whatever the event of the dispute, the prize of victory would perish in the struggle." To avert this catastrophe, and to obtain the indispensable increase in industrial efficiency, industrial unrest must be removed; and its removal is "the fundamental problem, which is both the most important and the least recognised."

For immediate purposes special emergency measures are proposed, which relate to finding jobs, assuring decent wages, settling men on the land, teaching men trades, utilising the new factories, and disposing of workers who leave or are ejected from the war industries. Wages must be increased above pre-war rates in proportion to the increase in the cost of living, and men "who work at a staple trade will, of course, look for the standard rate of wages current at the date of their return." Minimum rates might be imposed in many of the feebly organised trades, but not in those in which they "would represent an increase in the cost o

* *Memorandum on the Industrial Situation After the War.* (*The Garton Foundation.*) London: Harrison & Sons, St. Martin's Lane, W.C. [Price 1s. net.]

production and selling prices, and simply become a tax on the community as a whole for the benefit of the workers in a particular trade." If, however, employers and employed could be brought into a right co-operative relation, friction over wages would be less likely, and workers would have a better chance of an all-round improvement in their condition, "due to increased efficiency of production."

The constructive measures are mostly indicated only in outline. Their discussion includes provisions for assuring improved health and physical efficiency, increased technical and "civic" education, labour-saving machinery, works organisation, labour legislation, patent-law reform, research, methods of distribution, banking and credit facilities, provision of capital by savings, assurance of home, imperial and foreign markets, the political and economic aspects of an allied Zollverein, the land question, and the organisation of and education for agriculture. As the authors point out, much of their discussion merely indicates subjects for study or describes what has been described more fully by others. It amounts, in fact, to a *catalogue raisonné*, which has the merit, among others, of exhibiting the complexity of the situation; an aspect which is the more important because its factors, though they may be discussed separately, must operate together, and measures cannot be adopted prudently for one factor without first having been brought to a balance with the others. The discussion is most complete on the questions that affect labour, which may now be described.

(*c*) *Labour-Saving Machinery.*—An increase in output, quickly repaying its cost, could be obtained by the wider use of labour-saving machinery. The men resist, obstruct, or at least resent it; and this less because it reduces their money than because it touches their self-respect, and its mechanical routine tends to dehumanise them during their hours of labour. "This feeling is not only a natural one, but is based on a sound instinct"; but there would be no reason for it if only "more care were taken to explain to operators the purpose of their work and the part it plays in the mechanism of production." On the economical side, though the men attach less importance to it, they have more solid grounds for suspicion. A man fears that the machine may lower his wages or deprive him of his job, and must in any case destroy the monopoly-value of the skill that is his stock-in-trade, so reducing him to the level of an unskilled man. Such hardship, however, though it is inevitable in all progress and in any sudden change, does not prove that machinery which increases production injures Labour as a whole in the long run. It must be recognised that to resist the forces of change is impossible, and even to retard them is wasteful. "The better course is to develop the new trade or system rapidly and efficiently," doing what may be possible to mitigate individual hardships. The opposition of the men must be met by discussing with them "through their representatives and their trade union the machinery required to meet the demands of competition, the rate of its introduction, the conditions under which it is to be worked, and the wages to be paid. . . . At the same time a better system of education, tending to produce all-round competence and adaptability, would go a long way towards placing the worker above the prospect of disaster due to a change of conditions."

(*d*) *Works Organisation.*—An analogous way of increasing output is what is known in America as scientific management. In this "the whole routine, down to the last detail of every operation, is organised by the management, operating through a staff of efficiency experts." This process of minute regulation includes not only the "routing"* of work through the shops, but also the way in which each worker's job is done. Men are trained to work to a schedule expressing the ascertained best way, as a boat's crew is trained by a coach. "No overstrain is allowed; rest periods are provided. An astonishing increase of output can be achieved along these lines; so that unprecedently high wages can be and are paid to those who will work under the system." Yet the men detest it. Their least ground of objection is the "natural soreness" that the employer makes more by the system than their own gain, large though it is. Their main reason is their aversion to "becoming a mindless automaton," gaining no general proficiency, shut out from a higher grade of employment, using methods prescribed not by the traditions or masters of their craft, but by an outside scientific expert. The system cannot, in fact, be introduced without the voluntary co-operation of the men; and that co-operation can be secured only by submitting the proposition to them frankly, and "transforming the whole constitution of the works in such a way that the men themselves may have an interest in the new system and some share of control over the working of it."

(*e*) *Labour Legislation.*—"It is clear that organised bodies of workers and employers must in the immediate future play a greater part in the history and direction of our economic life. . . . Only a quarter of the whole working population is enrolled in trade unions," and through mere anomaly and historical accident different standards and conditions have been established. By remedying these inequalities, by further limiting hours, by compelling the provision of far healthier workshops with dining and rest rooms, "labour legislation should be thoroughly overhauled and strengthened to meet the demand for a higher general standard of life, in such ways as will increase the self-respect, dignity and efficiency of the protected workers. . . . All modifications and developments should be based in the first instance on the joint recommendations of employers' associations and trade unions."

(*f*) *The Interests of Labour and Capital.*—The agreement between Labour, management and Capital that will avert catastrophe must, however, go beyond special measures. It must define the future organisation of industry; and the first condition of agreeing upon such a definition is to understand the common and the separate interests of the parties.

The most vital necessity is that the work and its conditions shall be such as to make the workers feel it to be a fit and worthy occupation, and to lead them to be intelligent and self-respecting citizens. The conditions of material well-being, though different from the conditions of satisfying this necessity, and secondary in importance, are not incompatible with them. These conditions require the output of goods and services to be a maximum, waste of material and effort a minimum, the supply of capital sufficient, and the distribution of the proceeds of industry fair. "The amount available for distribution depends on the amount produced"; and any scheme of redistribution of income that ignored the necessity for fresh productive effort would tend to reduce the total available for division. To restore the depleted national capital increased production must be accompanied by increased saving and investment in productive industries, for from no other source can fresh capital be had; and such investment can be induced only by increased confidence.

Except when exploiting monopolies, on which proper limitations must be put, employers as a rule are interested in increasing output, and the only obstacles from their side to such increase come from inefficiency; including not only obsolete plant and methods and "the presence of 'dead-heads' on the office staff," but also an unconscious aversion to making the most of their best men by letting them earn wages proportioned to their skill. On the other hand, employers are not necessarily interested in maintaining a high standard of quality.

The limitation of output by Labour arises from three main causes. The first is the wish to avoid overwork and insufficient leisure, as social welfare requires them to be avoided. Large sections of Labour also deliberately limit output in the "mistaken belief that the less each man does, the more work there will be to go round"; ignoring the fact that wages come only out of product, and their total amount can be increased only by increasing production. The policy is wasteful, and must be met by giving workers greater security of tenure. Limitation of output is also practised for fear that the standard of the best man may be imposed upon all, the average man thus suffering either excessive strain or lessened earnings; and "Labour cannot fairly be asked to remove" these restrictions without "some definite assurance against the evils anticipated." The wages of Labour, with its status and men's interest in their work, would, however, be improved if Labour organisations would give more attention to questions of craft-training and quality of output.

The net outcome of these considerations is that the interests of Labour, Capital, industry and the nation require an unrestricted and efficiently-produced output of high or even improved quality, and that the policies of limiting production and of cutting wages must equally be abandoned; that, in short, every man must work and earn to the full extent of his ability. This condition can be fulfilled only by solving the problem of the relations between employer and employed. On the economic side this should not be difficult. The interests of both sides are concurrent as regards production. Each demands the largest possible total for distribution, and Labour as consumer shares in the benefit of increased efficiency in production. Even in distribution their interests are only partly antagonistic. Within each trade employers need men whose conditions of life make them able and anxious to do their best, and men need employers prosperous enough to give continuous employment. Within industry as a whole, again, both employers and employed in each trade are interested in good wages being paid and good profits earned in every other trade, so as to maintain the purchasing power of their customers and the producing power of their suppliers.

* Determining the route; not, as some industrial leaders have seemed to imagine, routing or hustling up. An essentially methodical process, it is the exact antithesis of the succession of spasmodic activities that constitute hustling.

THE EXTENSION OF THE TOTTENHAM DISTRICT LIGHT, HEAT AND POWER COMPANY'S WORKS.

IN our issue of June 22 we gave a general account of the works of the Tottenham District Light, Heat and Power Company's works, with special regard to the extension which has recently been made. Supplementary to this we published on July 6 detailed drawings of the new gasholder, and in this issue we give drawings on the next page, and on our two-page plate, of the gas producers, and of the Woodall-Duckham vertical retorts.

The Tottenham Gas Works occupy a prominent place in the early development of the gas industry. Mr. Alexander Croll, the well-known pioneer in the industry, applied at Tottenham many of his epoch-marking inventions. In the year 1845 he was superintendent of the Brick-lane Works of the Chartered Gas Company, and obtained a concession from the Imperial Gas Company to supply the districts of Tottenham and Edmonton (which then included Wood Green and Southgate). He purchased a site for gas manufacturing purposes of barely 1½ acres, which is now at the extreme southern end of the works. It appears to have been chosen because it was then a coal yard contiguous to the Eastern Counties Railway, now a part of the Great Eastern System, and had a siding with unloading and storage pits; but being cut off from connection with the river by the railway, coal supply facilities were restricted. This has since been rectified by the present company having procured land on the opposite side as far as the river.

Mr. Croll's retorts were of the direct-fired clay type; others were of cast-iron. Ammonia was recovered by his system of washing the gas in water acidulated with sulphuric acid, which was subsequently boiled down and the sulphate of ammonia obtained. Purification was effected by means of oxide of iron. In the year 1844 Mr. Croll patented the dry gas meter, of which he was the joint inventor with William Richards. At that period Mr. Croll and Mr. Thomas Glover founded the Clerkenwell wet meter business under the style of Croll and Glover.

The original works at Tottenham, which were designed and erected by Mr. Croll, were taken over by a company formed for the purpose, with a nominal capital of 20,000*l*. He was soon afterwards

GAS PRODUCERS; THE TOTTENHAM LIGHT, HEAT AND POWER CO.'S WORKS.

MR. A. E. BROADBERRY, M. INST. C.E., CHIEF ENGINEER; THE POWER GAS CORPORATION, LTD., STOCKTON-ON-TEES, CONTRACTORS.

Fig. 57.

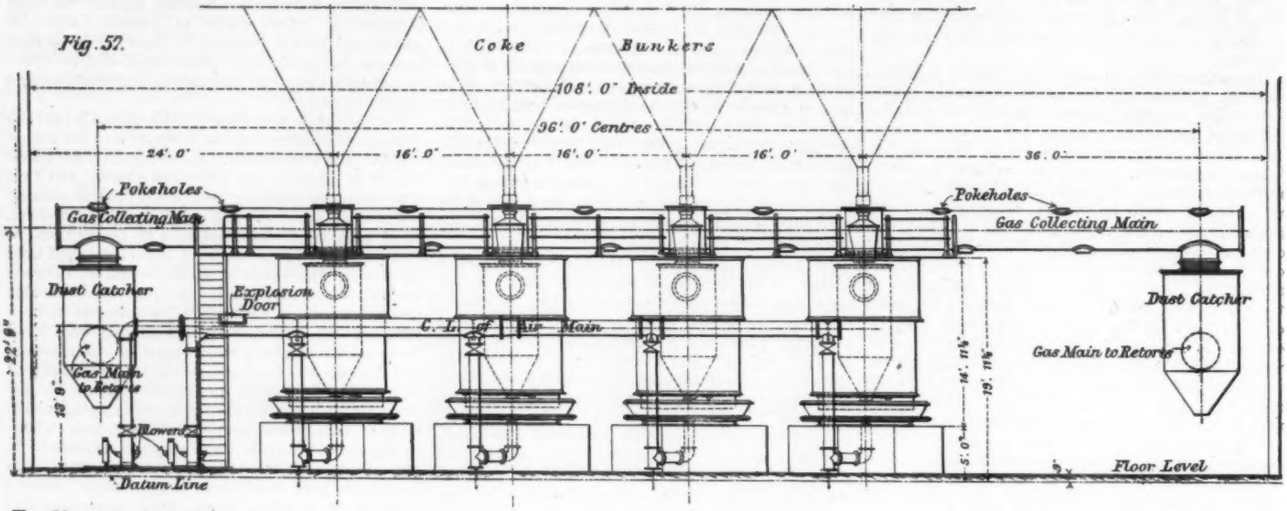


Fig. 58.

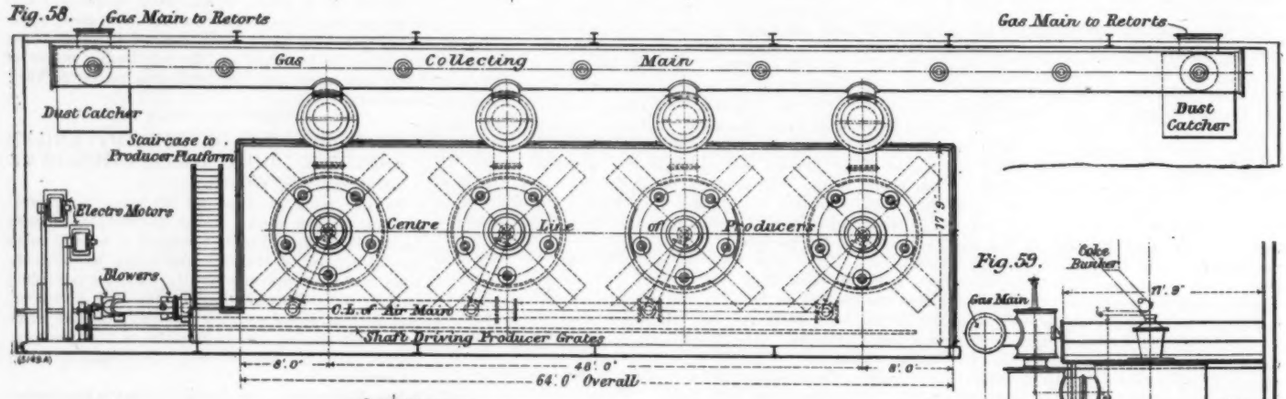


Fig. 59.

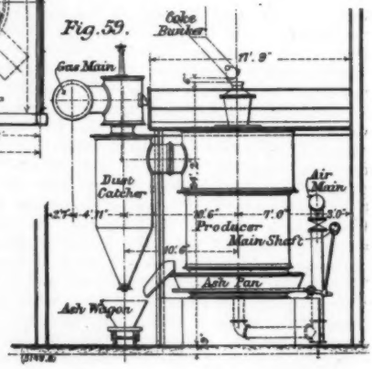


Fig. 60.

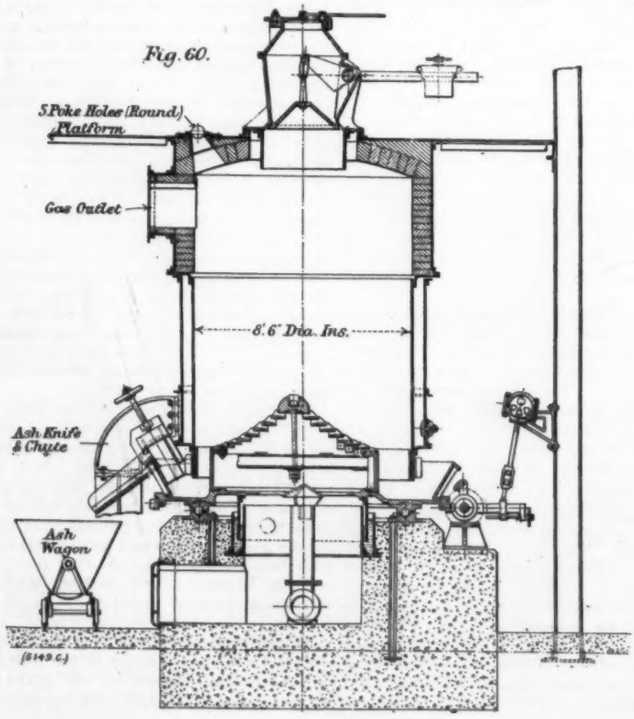
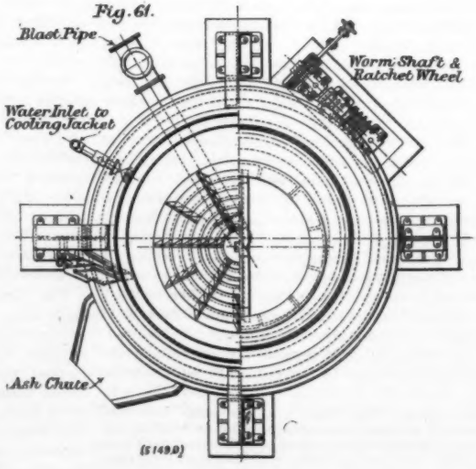


Fig. 61.



actively engaged on the formation of the Great Central Gas Consumers' Company, to supply to London cheap gas at 4*s.* per 1,000 cub. ft. in competition with other existing undertakings, whose price was 6*s.* Mr. George Anderson, who was appointed by Mr. Croll as manager at Tottenham, assisted him in his various enterprises, which resulted in the erection of many gas works on the Continent and in Ireland. The early work of British gas engineers, as also that of those of later generations, is much in evidence in France, Germany, and other continental countries.

The Tottenham company continued its existence as a non-statutory concern until 1859, when Royal assent was given to its first Act of Parliament. The maximum price of gas was then fixed at 6*s.* per 1,000 cubic feet and the illuminating power at 11 candles. From 1874 to 1899 the late Mr. W. H. H. Broadberry, father of the present chief engineer, filled the post of engineer and manager. During that period the output grew from 91,000,000 cub. ft. per annum to 575,000,000.

The new manufacturing area of the works is 31½ acres in extent. Additional spare land of 48½ acres has also been acquired for future extensions. The High-road site for the very fine block of office and depot buildings, which was opened in 1901, covers over an acre, and the site of the station at Wood Green, opened in 1883, is a quarter of an acre in area. A further depot was subsequently opened at Winchmore Hill, and additional show rooms at Wood Green. The authorised stock and loan capital of the company is 1,948,705*l.*, of which 1,210,408*l.* has been issued. Gas is sold at 3*s.* 4*d.* per 1,000 cub. ft. in the Tottenham area, and at 3*s.* 9*d.* in the Enfield area.

The present total output of the works is 2,701,601,000 cub. ft. per annum, 1,793,464,000 cub. ft. being coal gas and 908,137,000 cub. ft. carburetted water-gas. The sale in 1914 was 2,279,000,000 cub. ft., in 1915 it had increased to 2,351,000,000 cub. ft., and in 1916 to 2,701,000,000 cub. ft. A large proportion is consumed for munition and general industrial purposes. The pressing necessity for the additional plant which we have described is thus apparent. The company, on January 1, 1914, took over the Enfield Gas Company's area, with works at Ponders End. These it is intended to close down as soon as the plant at Tottenham can deal with the whole load.

The position of secretary to the company was held by the late Mr. E. Topley from 1907 till his death last year. He was previously assistant secretary under Mr. James Randall, who held the office for many years. The present secretary is Mr. E. J. K. Fussell.

On the opposite page illustrations are given of the outside gas producers from which the retorts are heated. The producers are four in number, and were constructed by the Power Gas Corporation, Limited, of Stockton-on-Tees. Each will gasify 20 tons of coke breeze per diem.

As will be seen from Figs. 57 and 58, showing side elevation and plan, they are erected in a row, an operating platform being common to all. The gas outlets are connected, through dust catchers and valves of the mushroom type, to a common collecting main. A sectional elevation and plan of one of the producers are given in Figs. 60 and 61.

Two steam turbo-blowers, each capable of meeting the demands of three producers, provide blast for the plant. Referring to Fig. 60, the rotating grates are operated by electric motors, which are installed in duplicate, one being spare; the drive is by belt. It will be seen that in this type of producer there is a combination of steel shells having a lower portion water-cooled and the upper part lined with refractory brickwork. Each producer has a rotating grate, Fig. 61, mounted eccentrically on a water-luted ash-discharge pan. The steel shell has the water-cooled metal surface in that zone of the producer where clinker usually forms, thus preventing clinker from adhering to the walls.

With the gradual descent of the fuel the clinker falls to the rotating grate, where it is crushed against the specially-prepared grinding surface at the bottom, and passes into the luted pan, Fig. 60. When the producer is operating the pan fills up with mixed crushed clinker and ash, which, as the pan revolves, is forced against a stationary adjustable plough blade, and is discharged on to the ground; or, as is usually arranged, into ash trucks alongside the producer. The air blast enters underneath the grate, Fig. 60, and passes up to the cone of the grate, and through this on to the fuel bed.

The grate, with ash pan rotating on a ball-race, is actuated by worm gearing fitted with variable-feed ratchet attachment, arranged for driving by eccentric and rod from a shaft alongside the producer. There are the usual fittings—hopper with lever-operated cone valve and balance-weight; cover, top ball poke-holes, &c.

The water outlet is arranged so that the jacket is always full of water and free of any air space, thus minimising the possibilities of corrosion. The water which is discharged provides a supply of hot water, which may be used for boiler feed or other purposes on the works.

The gas from each producer passes through a "Cyclone" dust-extractor into a trunk main, and thence through two other dust extractors into mains running along each side of the retort-house, and on to branch mains, which are situated between the coke-receiving hoppers under the retort benches. The breeze and very fine coke from the coke screens is elevated to a band conveyor, and is delivered to the hoppers above the producers. These hoppers can be supplied either with coke direct from the retorts or with breeze screened from the coke.

So that the results obtainable from the breeze available at the Tottenham Company's works might be ascertained experimentally, a quantity was sent to the makers of the producers, and gasified by them. The tests showed that 110,000 cub. ft. of gas could be produced from 1 ton of wet breeze. The analysis of the gas gave CO_2, 6.4 per cent.; CO, 25 per cent; and H_2, 14 per cent. The ash was 87.3 per cent. incombustible; carbon, 10.73 per cent. The calorific value of the fuel was 11,109 British thermal units per pound on a dry sample. The net calorific value of the gas produced was 124 British thermal units per cubic foot.

The Woodall-Duckham vertical retort installation which has been adopted consists of 56 retorts, each capable of carbonising 6½ tons of coal per 24 hours; or a total of 364 tons of coal; and yielding 4,500,000 cub. ft. of gas during that period.

As shown in the engravings on Plate XIV, the retorts are arranged in two parallel benches of 14 settings (Figs. 62 to 64), each setting containing two retorts. The retorts are 26 ft. long, and in cross-section are rectangular, measuring 5 ft. 3 in. by 7 in. at the top, increasing with varying tapers towards the bottom, so as to ensure that the coal travels continuously and freely by gravitation through the retorts (Figs. 66 and 67).

Six to seven hours are taken by the coal in descending through the retort. It is fed continuously at the top by means of auxiliary hoppers. By the time it has reached the bottom practically the whole of the volatile matter has been driven off, and there only remains a good, clean, and bright coke to be discharged. The coke at this point is practically cold, having been cooled in the lower portion of the retort, which is built in the form of a regenerator. The heat in the coke is utilised in increasing the temperature of the secondary air and also that of the gas from the outside producers, which are employed for heating the settings. These producers were described, with drawings, in our issue of June 22.

The cycle of operation of this most recent vertical retort installation is as follows:—Referring to Figs. 62 to 65, railway wagons containing the coal are hauled by the gas company's locomotives to the wagon tipplers situated outside the retort-house. These tipplers are hydraulically operated, two sets being supplied, one right and one left-hand, to each coal-receiving hopper. The wagons are end-tipped into the hoppers, and the coal, by means of jigging screens, is delivered into the coal breakers, which each have a capacity of 100 tons per hour. From these two breakers the coal is delivered into gravity-bucket conveyors, which encircle each bench of vertical retorts.

The conveyors deliver into a line of coal bunkers built above the retort settings. The bunkers have a capacity equal to 48 hours' supply for the retorts. By means of a travelling dumper and shoot the coal can be delivered into any section of the bunker as required. From these bunkers the coal is fed every four hours, by means of a special gastight coal valve, into the auxiliary supply hoppers attached to the top mouthpiece of the retorts. From these auxiliary hoppers the coal flows continuously, by gravity, into the retort (Fig. 66).

The rate of travel of the coal into the retort is regulated by the rate of extraction of the coke at the bottom. It will therefore be seen that the speed of operation is entirely dependent on the speed of coke extraction. As will be seen from Figs. 68 and 69, the patent coke extractor of the Woodall-Duckham Company is a very simple arrangement, comprising a curved sloping plate which takes the weight of the charge in the retort. The speed at which the coal is allowed to slip over this plate is regulated by weighted hangers and a revolving helical screw. This screw is formed with a plain, square shaft having cast-iron crosses slipped on, the hole on the boss of each cross being staggered a little more than its neighbour, so that the arms form a spiral.

The extractor screw allows the coke to flow over it at any desired rate according to the speed at which it is rotated, the speed of extraction having to be varied according to the class of coal that is being carbonised. The normal speed is about one revolution in 55 minutes; it can be varied about 50 per cent. faster or slower. The mechanism for operating the extractors is somewhat novel, owing to the unusually slow speed required, and may be described as follows:—Across the end of each bench is a countershaft rotated at about one revolution per minute. It is driven by gas engines through spur and worm gearing in the usual manner. On this shaft are fitted adjustable eccentrics which in turn operate twin longitudinal push bars running the entire length of the bench. The bars have a backward and forward motion of 4 in.

The screw shaft of each coke extractor is extended through the extractor box castings, and has keyed to it a wheel with a V-groove machined in its rim. The boss of this wheel is machined, and fitted to it are two arms which rotate on the boss, one on each side of the wheel. The top end of the arms is fitted with a quadrant-shaped pawl, having the edge machined V-shaped similarly to correspond with the rim of the wheel. The bottom end of this arm is attached, by means of a connecting rod, to the push bars, and each time the bar moves forward the pawl engages the wheel and rotates it during the forward motion of the bar. Immediately the motion of the bar is reversed the pawl disengages and returns ready for another stroke. To prevent the wheel coming back with the pawl a second, or back-lash, pawl is fitted, and comes into operation when the wheel attempts to turn backward.

The coke, after passing the extractor, falls into a receiving hopper, which holds about four hours' discharge. The bottom of this hopper is kept gastight by means of a water-sealed door. Each fourth hour the attendant opens the door by hand, and the contents of the hopper are discharged, through a special travelling shoot, into the gravity-bucket conveyor, which delivers the coke into coke hoppers above the retort settings, and which are used for filling the retorts with coke after scurfing. The conveyor can also deliver the coke on to a longitudinal tray conveyor situated across the end of the house, as shown in the plan, Fig. 63, and transverse section, Fig. 64. This conveyor has a capacity of 100 tons an hour, and will deliver the coke in either of the three following ways:—(1) Into a shoot on to a fixed band conveyor that in turn will deliver into the hoppers feeding the gas producers; (2) into duplicate patent jigging screens that grade the coke into four different sizes and deliver it into bunkers arranged for taking delivery of the graded coke; (3) into a small reserve hopper at the end of the conveyor, from which it can be taken for any purposes required on the works.

The breeze screened from the coke is diverted into two special compartments, and by means of a shoot can be delivered into an elevator, which in turn will lift it on to the band conveyor supplying

the hoppers over the producers, so that breeze or a mixture of breeze and coke can be gasified in the outside producers.

The gas from the producers is taken through firebrick-lined steel mains fitted with dust-catching apparatus into the retort-house to the underside of the settings. Small branch pipes are taken from the main gas mains to supply each retort with gas, and are fitted with valves so that the supply can be regulated. The gas, as previously stated, is heated by means of the cooling coke at the bottom of the retort, before being taken to the combustion chambers and ignited.

INDUSTRIAL NOTES.

We give below brief abstracts from the divisional reports of the Commission on Industrial Unrest, which were published last Tuesday:—*North-Eastern Area:* Commissioners, Sir T. Munro, Mr. P. Bright and Mr. H. Davies. Food prices are the most general cause of unrest. It is believed that prices are enhanced not only by scarcity, but by profiteering unchecked by courageous Government action. No sections of the industrial classes, apart from a small minority, are unprepared to take their part in military service. There is little real objection to dilution. The restoration of pre-war conditions is probably the question which most exercises the minds of both employers and employees. Prompt inquiry into and redress of grievances is stated as the best way to secure proper shop discipline. *North-Western Area:* Commissioners, Judge Parry, Mr. J. Smethurst, and Mr. J. R. Clynes, M.P. The permanent officials of all Departments in London should deal with complaints promptly, sympathetically, and in a business spirit. The patriotic spirit of men and employers is manifest. Anger is felt at the high cost of living and the Government will be expected to deal firmly with every vested interest which stands between the food supply and its distribution. Men of broad outlook should be placed in command in the different centres; their decisions should be upheld; it should be known in every Government Department in London that during the war what they say is to be done must be done at once, without any unnecessary departmental interference. In Barrow-in-Furness the housing conditions are a crying scandal. *Yorkshire and East Midlands Area:* Commissioners, Sir G. Croydon Marks, M.P., Sir Maurice Levy, M.P., Mr. J. J. Mallon and Mr. A. J. Wadeson. Complaints are numerous as to food profiteering, coupled with statements to the effect that discomforts would be borne with comparative composure if they were felt necessary to win the war. Many preventible causes, including constant indifference to their complaints, have made the men weary and suspicious, and have fostered the belief that a strike was the only means of securing redress. *West Midlands Area:* Commissioners, Mr. J. W. Hills, M.P., Mr. J. W. Ogden and Mr. J. W. White. The men are entitled to ask, and do ask, that sacrifices should be equal and should be imposed for national and not class interests. There is little trace of disloyalty or slackening of the national determination to finish the war. A great part of the unrest caused by the Military Service Act would have been avoided had the Government been more open with the public. The men are still suspicious of women's work, partly because it is an innovation and partly because they feel that it will reduce rates. Besides anger at high prices, there is bitter resentment at the thought that someone is making excessive profits. It is absolutely necessary that Government should take immediate steps to reduce prices and prevent profiteering. *London and South-Eastern Area:* Commissioners, Judge O'Connor, Mr. A. M. Smith and Mr. J. Voce. The men realise the impossibility of maintaining pre-war food supplies or prices, but they are convinced that the present prices are far higher than they should be. Since the war there has gradually arisen a feeling that there is a tendency to treat them as though they were rather the instruments of the community than members of it. The leaving certificate system, the differentiation between day rates for skilled men and piece rates for semi-skilled and unskilled, and other factors are mentioned as instances of inequality of sacrifice. The growth of officialism, the multiplication of Departments, and the continual changes in personnel, have resulted in loss of confidence in the Government's dealings with labour problems. This is associated with diminished reliance on the power and prestige of the trade unions, the impairment of the authority of their executive bodies, and the development of the shop steward movement. There have been vexatious delays in procuring settlement by Government Departments. *South-Western Area:* Commissioners, Mr. W. W. Mackenzie, Sir Alfred Booth and Mr. T. Chambers. There is a widespread feeling among the working classes that too great a share of the financial burden is falling on them. We have made a serious mistake in making the excess profit duty the corner-stone of our war taxation. It does not take money from the rich man's pocket as a direct tax on his income would have done, and it has failed in its moral effect on the working classes as a symbol of equality of sacrifice. *Scotland:* Commissioners, Mr. T. A. Fyfe, Mr. N. E. Peck and Mr. A. G. Cameron. The fundamental cause of unrest is the increased cost of living; in the mind of the workers this is the result of the Government having failed timeously and effectively to control production, supply and distribution. But the actual increase in the cost of living does not appear to be so important a factor in the workers' minds as the belief that profiteering exists. Housing accommodation is greatly lacking.

The Home Secretary has given notice that he proposes, in pursuance of the powers conferred on him by the Police, Factories, &c. (Miscellaneous Provisions) Act, 1916, of making an Order—to take effect from October 1 next—in regard to ambulance and first aid at all factories employing 25 or more persons which belong to one or other of the following classes: blast-furnaces, copper mills, iron mills, foundries, metal works. The proposed Order will impose obligations on the occupiers of these works in respect of the provision and maintenance of first-aid boxes or cupboards, and, in the case of factories employing 500 or more persons, the provision and maintenance of an ambulance room and ambulance carriage. Copies of the draft Order—price 1*d.* each (by post 1½*d.*)—may be obtained from H.M. Stationery Office, Imperial House, Kingsway, London, W.C. 2, and 28, Abingdon-street, London, S.W. 1; 37, Peter-street, Manchester; 1, St. Andrew's-crescent, Cardiff; 23, Forth-street, Edinburgh; or E. Ponsonby, Limited, 116, Grafton-street, Dublin; or through the usual agents.

Any objection to the proposed Order must be sent to the Secretary of State at the Home Office, Whitehall, London, S.W. 1, within 21 days after the date (July 27) of the notice. The objection must be in writing and must state: (*a*) the requirements in the draft Order objected to; (*b*) the specific grounds of objection; and (*c*) the modifications asked for. Where an objection is made jointly on behalf of a number of occupiers, the names of the occupiers and their addresses must be stated, or if the objection is made by an association of occupiers on behalf of its members, the number of the members affected by the Order.

In the course of the annual meeting of the Gloucester Railway Carriage and Wagon Company, Limited, which was held last Monday, the chairman, Sir Richard Vassar-Smith, referred to the Federation of British Industries. This, he stated, had greatly developed of late, there being about 500 federated associations and firms. It had become a power in the industrial administration of the country. The Government, recognising it as such, submitted to it questions in connection with labour, among other matters. At a time when there were so many problems affecting capital and labour to be faced, it was absolutely necessary to have organisations both of employers and employees to discuss those problems. With a large number of manufacturers working alone and of men working outside the trade unions it was difficult to make the necessary arrangements and to keep the arrangements that were made. In connection with the federation there had been formed a National Alliance of Employers and Employed for discussing the questions which were agitating both capital and labour. It was proceeding harmoniously, and he thought there was on both sides a very strong intention to see that matters were so arranged that work should henceforth proceed more amicably than it had done in the past.

The half-yearly meeting of the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England was held on Monday last, in the Central Station Hotel, Newcastle, says *The Newcastle Daily Chronicle*. Mr. J. Reay, Stockton, presided.

The Standing Committee reported an accession to the membership of the board during the half-year, Messrs. Raine and Co., Limited, of Derwenthaugh, and their workmen having been accepted in March last. This made the membership ten works, owned by eight persons. The average number of operative subscribing members showed an increase of 198, the members now being 3,214. In the six months an application for a war bonus to non-scale men had been considered, when it was decided that there be an additional war bonus of 6*s.* per week to men whose wages did not fluctuate with the sliding scale. The bonus to youths was at the rate of 3*s.* per week. Four ascertainments of the average selling price of finished iron had been received since the annual meeting. Wages had been advanced by 7½ per cent.

The chairman moved the adoption of the report, and welcomed Messrs. Raine and their employees. He spoke of the continued good relationships between employers and employees represented on the board, and, dealing with the wages of iron and steel workers, he said the increases in the half-year, as shown in the report, amounted to 7½ per cent., making a total increase of 67½ per cent. since August, 1914. Regarding the outlook for trade, he added that they had been all very busy, and were likely to be busy for some time to come. The great majority of the men were working satisfactorily, but there were still some who did not seem to realise yet that we were in the midst of a great war, and that it was imperative for everyone to put forward his maximum effort to try and help to beat our enemies. He thought the least we could do who were living in comfort and peace at home was to work as hard as we could, and as regularly as possible, and thereby help our relatives and our friends who were trying to win the war. They should also remember that much of the material they produced was needed for the shipbuilding programme, and therefore no effort should be spared to bring the war to a speedy and satisfactory conclusion.

Mr. W. T. Griffiths, from the men's side of the board, seconded, and remarked that the principle for securing good relationship between employers and employed recommended by the Government Reconstruction Committee was very much the same as had worked so well in the iron and steel trade in the last 40 years; and this reflected a great tribute to the success of their Conciliation Board.

The report was confirmed.

The secretaries of the Midland Iron and Steel Wages Board have issued the report of the accountants for the two months May and June last, adding that in accordance with the sliding-scale arrangements the wages for puddling during the months of August and September of the present year will be 17*s.* 6*d.* per ton, all other mill and forge wages remaining unaltered. The new wages are to take effect from Monday next, the 6th inst., and to continue until Saturday, October 6. To the 17*s.* 6*d.* per ton under the sliding scale there is to be added 6*d.* per ton bonus granted to the puddlers by a resolution of the Wages Board, which met on July 15, 1912. This bonus applies only to puddlers, and makes the total puddling rate 18*s.* per ton. The average net selling price for May and June of bars, angles and tees, plates and sheets, hoops, strips and miscellaneous, was 15*l.* 6*s.* 0.88*d.* It was 15*l.* 4*s.* 11.87*d.* for the preceding two months.

The thirty-fifth annual report of the Ship Constructors' and Shipwrights' Association states that the membership at the commencement of 1916 was 29,563; it reached 30,970 at the end of December. The income of the association for the year, apart from the operations under the National Insurance Act, has been 83,193*l.*; the expenditure for the year reached 64,512*l.* The association commenced the year with a balance in the reserve fund of 176,084*l.*, and at the end of 1916 the reserve fund reached 194,765*l.*, which is separate from the political fund.

In the course of his review for the year the general secretary states that the industrial organisations of the country, broadly speaking, have shown a considerable increase financially and numerically, and it is evident by these facts that the industrial classes of the country generally are recognising, notwithstanding the war, that industrial organisation, whatever it may have been in the past, with all its limitations, has been a powerful factor in dealing with many intricate and difficult problems which have arisen during the war, and will be of still paramount importance when the war has come to an end.

One of the greatest stumbling-blocks in the way of rapid and economical manufacture of munitions, says *The American Machinist*, is the problem of inspection. The indiscriminate placing of close tolerances on parts that did not require them has been responsible for much of this difficulty, but this absurdity promises to be largely eliminated as a result of the work now being done on specifications for our own (the American) munitions. Then, too, the average man assigned to inspection work has not had the experience, even if he has the authority, to discriminate between the essential and the non-essential dimensions. This matter is something that can be taught in the technical-school shop, so that engineer students can be used to advantage in work of this kind, often releasing an officer for work at which he can be of greater value to the country. As an illustration, our American contemporary instances the difference in the degree of finish permissible in a shell as compared with that required for a gun.

It must not be forgotten, it is added, that much of

the over-zealous inspection has been brought about by the sometimes successful attempts on the part of contractors in the past to put something over on the Government, to turn out inferior work and sell it for a good price. This desire, it is further stated, is fortunately very little in evidence at the present time, and there is a widespread movement to give the Government exactly what it wants at a fair price. This spirit can be encouraged by eliminating any unnecessary requirements; and, on the other hand, the surest way to have severe inspection specifications modified is to make it a practice to turn out work that meets the main requirements in all tests.

We are glad our contemporary has raised the point, for some Government specifications are in urgent need of revision, and this fact, coupled with the "overzealousness"—or the "lack of experience and of authority of the present average man assigned to inspection work"—has been responsible for an immense amount of waste. But we do not agree with him when he impugns the integrity of contractors. These have their reputation to maintain; besides this, the works who have always made a speciality of munition manufacture have had to face for years past a most strenuous competition, which has led them gradually to perfect their material and processes. This and their patriotism render, we fully believe, an inspection of their products quite unnecessary, and the inspection of the products manufactured by the present "casual" munition works might well be left to inspectors selected from our "habitual" munition works, to the exclusion of all military inspectors, who would then be available for the front, where, like their colleagues, they would render admirable service.

CORROSION OF CONDENSER TUBES.

To the Editor of Engineering.

SIR,—It was with great interest that I read an article on the above subject which appeared in your issue of July 13, 1917, and I hope that the author may find in the case that I am about to quote and in the deductions drawn therefrom enough hypothesis to interest him sufficiently to conduct experiments on the lines which I have attempted to indicate.

Mr. Ramsay, in his article, does not carry conviction to my mind that the cause of the deterioration of the tubes is electrolytic; in fact the article seems in its inception to have premised the electrolytic theory, and the actions observed, with the deductions drawn therefrom, appear to have been marshalled in such a way as to point to electrolysis. Where, however, observed facts refuse to fall into line, some not easily understandable secondary action is inferred.

To make a bald statement of the opinion which I formed some years ago, and which I am afraid has undergone no radical change since reading the article referred to, the corrosive action which takes place is not electrolytic, but is in the main a mechanical action, or perhaps it were better called a mechanico-chemical action; and if electrolysis does enter into the question it does so to so small an extent as to be almost negligible.

I propose to give a case in my own experience of the complete breakdown of a large condenser after only a few months in service, and an account of some experiments which were carried out, at my request, by a friend of mine in the Royal School of Mines, leaving readers to form their own opinion on the merits of the two theories—the electrolytic and the mechanical.

The condenser referred to was part of an installation which was new, having been in service only about eight or nine months when the first condenser defect made itself known. A rapid test evinced the cause, a split or perforated tube, which was plugged, and the condenser brought into action again. After a very short interval the same thing occurred again, and, indeed, with ever-increasing rapidity perforated tubes were being discovered, no longer singly, but in twos and threes, until eventually, whenever the condensers were brought into action they failed through the perforating of tubes.

Several tubes were drawn and cut up, and it was found that in every case where a hole had developed very active corrosion had been taking place in the immediate vicinity of the perforation; and in nearly every case there was found wedged in the tube at the position of the perforation a small piece of coke or cinder (carbon).

The condensers were of the single-flow type, with tubes horizontal, the water passing through the tubes, and all the tubes affected were in the lower portion, which complies with the theory that the cinders were sucked in at some time by the circulators and although settling rapidly had not reached the bottom of the water chamber before being carried into the tubes.

When it became apparent that the corrosion was due to the presence of pieces of carbon in the tubes, the tubes were thoroughly searched with wire brushes, swept out with soft brushes, and eventually blown through with air to ensure their cleanliness. The condensers were then closed up and brought into action. Alas, the perforating process still went on, even after the removal of the supposed irritant, the fragments of carbon, and the condensers could not be relied on.

It was eventually decided to re-tube the lower halves of the condensers; that is, only that portion of the condenser to which it was considered the pieces of cinder could be carried by the circulating water. This was done, the upper halves remaining untouched, and as originally built. My own experience with these condensers extended for a period of two years after the re-tubing, and no single sign of weakness was ever discovered, and I believe that even now, after seven years, the condensers are still working efficiently and with the same tubes in them.

So far I appear to have made out a most excellent case for Mr. Ramsay's electrolytic theory, which I own was the one I jumped to at the time, forming in my mind-picture a most active little cell with the metal of the tube as the electro-positive to the carbon. This, however, did not seem to account for the fact that when the carbon had been removed from the tubes by the cleaning process mentioned above the action still went on in those tubes, and in those tubes only which had been, so to speak, contaminated by the carbon particles.

Now we arrive at the second or mechanical theory to account for the continuation of the action after the removal of the apparent cause.

A synopsis of the experiments carried out will best lead us to a conclusion, and this I now propose to give.

The composition of the material of which the tubes was made was found by analysis to be:—

	Per cent.
Tin	0.99260
Zinc	29.41600
Copper	69.40000
Total	99.80860

A piece of one of the tubes from the condenser was rolled out and polished, and two portions were cut from the sheet thus formed, exactly similar in every respect. To one of these portions a piece of coke was attached, while to the other no coke was attached; both portions were placed in a 2.5 per cent. solution of sodium chloride and kept at a temperature of about 90 deg. C. for about three days. At the end of this period no differentiation with respect to the rate of corrosion could be made, from which it was concluded that if electrolytic action was taking place it was exceptionally slow and only to be regarded as of secondary importance.

The theory was then advanced that the part played by the coke was purely mechanical.

A piece of the condenser tube was rolled and polished as before and two pieces were cut from it with as nearly as possible the same area, each piece was carefully weighed and the respective weights noted.

We will call the strips A and B. Strip A was placed in 100 c.c. of *airless* distilled water, to which had been added 2.5 grammes of NaCl, the other strip, B, was placed in a salt solution of the same strength, composition and volume, but through this solution *air* was *continually passing*.

Both pieces of brass in their respective solutions were then heated to the same temperature, about 90 deg. C. At the end of about six hours the pieces of brass were removed from their flasks, dried and weighed. It was then found that not only had the strips altered in weight by the dissolution of zinc, but that the piece which had been in the aerated water was corroded to such an extent that the polish was destroyed.

	Grammes.
Strip A before heating in airless solution	1.0866
Strip A after heating in airless solution	1.0862
Loss of weight	0.0004

Percentage of loss of weight, 0.0368.

	Grammes.
Strip B before heating in aerated solution	1.1802
Strip B after heating in aerated solution	1.1763
Loss of weight	0.0039

Percentage of loss of weight, 0.3313.

It would appear, therefore, that the rate of corrosion is dependant on the presence of air in the salt water. It was subsequently found that the solution in which strip A had been immersed contained a slight trace of air, otherwise it is anticipated that there would have been no loss of weight to record for strip A. Now we come to the mechanical part played by the coke in our condenser tubes.

It must be borne in mind that sea water contains air in solution, and that when this aerated water passes over a roughened surface, such as the coke, air passes out of the solution, with the formation of a bubble which may attach itself to the tube, and tends to oxidise the zinc in the brass. The bubble is then probably dislodged and with the $Zn(OH)_2$, formed in the presence of the moist air, is carried away in solution by the circulating water, thus rendering a new surface to be attacked by the air liberated mechanically by the coke; while the copper, after the removal of the zinc, would be so loosely attached to the body of the tube that some of it would be swept out in suspension by the stream of salt water passing through the tube.

Any of this copper precipitated on or in the vicinity of the foreign body would give the appearance of an electrolytic deposition of the metal.

Let us now go one step further and eliminate the coke, as was done in the case of the condensers to which I have referred, and in place of the coke we have the roughened surface of the tube, caused by the action started in the presence of the coke, acting in a manner similar to the coke in separating bubbles of air from the sea water, even holding the air in the tiny pockets already formed, and the action goes on, localised by the roughness of the tube.

This appears to me to be what happened in the case I have quoted, hence the continuation of the action after the removal of the coke.

If we accept the teachings of these experiments and apply in a generous spirit what would appear to be the action of the mechanically-liberated air from the circulating water on the material of the tube, we need take no flights into the realms of imagination to find reasons for the facts recorded by Mr. Ramsay that a substance which is known to be electro-positive to the brass should appear to act as electro-negative, and *vice versa*, nor need we have recourse to such an expression as "The action is probably a secondary effect due to copper being redeposited on the foreign metal."

We have only to bear in mind the fact that any irregularity, however small and apparently insignificant, in the smoothness of the surface of the tube acts to a greater or less degree as an air trap, and we have before us the necessary conditions for the corrosion of the condenser tubes, the gases in solution in the circulating water and the scouring action of the water keeping the spot where the action has once started from being coated with a preserving film of its own formation.

In conclusion I would ask your readers to apply this theory to any or all of the set of experiments quoted by the author of the paper, and everywhere do we find the action taking place at the position of the broken continuity of the surface of the tube, and almost, it would seem, with a rate in some way commensurate with the amount of disturbance of the harmonious flow of the water.

The solution of the problem from the practical engineering point of view seems to lie in the careful manufacture of the tubes, a perfectly smooth bore free from laminations, scoring or other unevenness, and care in keeping the tubes clean and free from pieces of any material which may become lodged in them.

Yours truly,
C. DE F. M.

To the Editor of Engineering.

SIR,—I am extremely obliged to Mr. Raymond for his most interesting letter which appeared in your issue of July 27, especially since his experience goes far to substantiate my own views.

The fact that sickness broke out in both French and British tubes about the same time is surely more than a coincidence. This, in my opinion, points to some change in the method of manufacture, and as one tube maker has frankly admitted to me that such is the case, the remedy seems fairly obvious.

Mr. Raymond's statement with regard to the superiority of amorphous over the crystalline tubes is worthy of closer attention. I have noticed something of the same kind in connection with micrometallurgy. At present we know very little about the physics of crystals, but I think there is some evidence that the orientation of the crystals in alloys has an influence on their rate of solution. I can perhaps convey this idea to the lay mind by the example of a stone wall in which the stones are laid heterogeneously and without reference to their natural formation. In such a wall the stones laid in their "natural bed" will resist weathering better than those laid otherwise. The comparison is not strictly analogous, but it will serve. I believe Mr. Arnold Philip, the British Admiralty chemist, was the first to bring forward this hypothesis, and I find myself in agreement with him. I have never actually observed that coarsely crystalline tubes corrode more rapidly than those with a finer structure, but I will certainly keep this point in view in the future, and I thank Mr. Raymond for his valued suggestion.

Yours faithfully,
WILLIAM RAMSAY.
23, Sycamore-road, Higher Tranmere, Birkenhead,
August 1, 1917.

ASCERTAINING THE CENTRE OF GRAVITY COMMON TO SEVERAL WEIGHTS.

To the Editor of Engineering.

SIR,—In my letter in last week's issue under this title, on page 101, I omitted to point out, in reference to Fig. 2, that, instead of drawing a special line along which to measure the weight C *d*, it is often convenient to utilise one of the already existing lines which radiate from C. For instance, C *d* may be measured along C *b*; D *c*, of course, being drawn parallel to it, on the opposite side of C D.

In the case of ships it will be found that by plotting the centre of gravity in this way on each of three views the positions found will exactly agree, if work has been correctly done; thus affording a useful check on its accuracy.

Yours faithfully,
C. H. WINGFIELD.

PERSONAL.—Messrs. Handcock and Dykes, consulting engineers, Westminster Chambers, 11, Victoria-street, S.W. 1, state that from October 1, 1917, they will have the advantage of the collaboration of Mr. A. P. Trotter, until recently Electrical Adviser to the Board of Trade. From that date the name of the firm will be Handcock, Dykes and Trotter.

SHIPBUILDING IN ITALY.—At present there are 15 steamers in course of construction at Italian yards. Of these, one boat of 10,500 tons and three of 5,700 tons each are being built at the yard in Riva; two steamers, each of 2,500 tons, are in course of construction at Palermo, and six boats of about 5,200 tons each at the yard of Ansaldo and Co. Of the above, about 40,000 tons are expected to be ready during the present year, against 60,000 tons in 1916 and 20,000 tons in 1915.

ACTIVATED SLUDGE SEWAGE PURIFICATION PLANT NEAR WORCESTER.

Fig. 1. SECTIONAL ELEVATION.

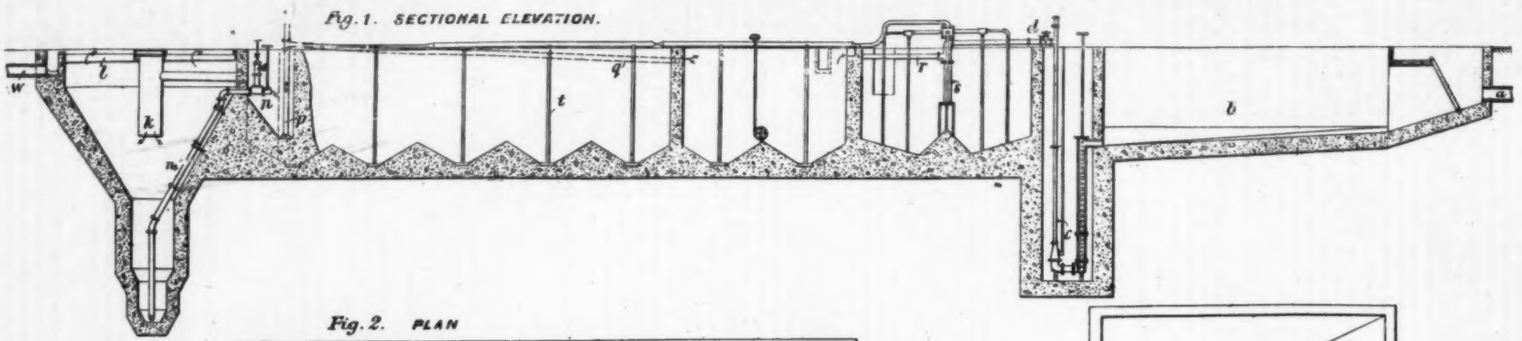
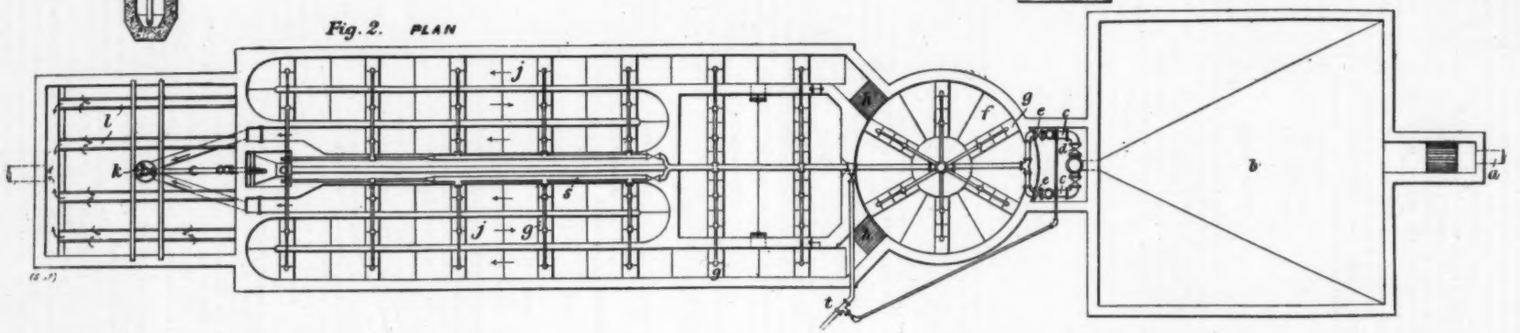


Fig. 2. PLAN



THE purification of sewage is being gradually changed from an agricultural operation into a factory process; that is, it is being converted from a procedure subject to all the vagaries of the weather in our fickle climate to one under complete control. In a rainless country the sewage farm, if of adequate size and of suitable soil, would work perfectly, but these conditions are hard to find. Sanitarians therefore welcomed with eagerness the bacterial filter, first on the fill-and-draw system, and later on the percolating system, as it promised to render them independent of the soil, and to a certain extent of the weather. The works could be erected on a small area, and kept under constant supervision, while the purification of the dry-weather flow, at any rate, was rendered fairly certain. The bacterial filter, however, has not altogether fulfilled the high hopes of its projectors. It is apt to clog and need renewal; the effluent often has to undergo subsequent settlement, and then there arises that perfectly intractable material, sewage sludge, which has been the despair of sanitary engineers in damp climates. The bacterial filter marked a great step in advance over the sewage farm, but everyone would be glad to see it superseded by something more uniform in its action and less liable to breakdown. It seems as if this desired attainment were on the eve of being realised by the activated sludge process.

We have quite recently given an account of the success attained by experimental plants in this country and America (see page 16 *ante*), but we may recall the fact that just as the percolating filter is the concentration of the land process, so the activated sludge tank is the concentration of the percolating filter. With it the purification of sewage becomes a manufacturing business. The raw materials are crude sewage and air, and the products are a clear stable effluent and an innocuous sludge. One could well dispense with the latter, but, at any rate, it is a very different material from the sludge of the past. It is granular in appearance, it drains rapidly, being gelatinous rather than colloidal, and analysis shows it to contain high percentages of nitrogen and phosphorus.

Sample of Sun-Dried Activated Sludge from the Stamford Sewage Works. Sent by Messrs. Jones and Attwood, Limited. Sample received June 28, 1917.

	Damp Sludge. Per cent.	Dry Sludge. Per cent.
Moisture	18.16	0.0
Nitrogen content	5.22	6.378
Phosphoric anhydride (P_2O_5)	2.81	3.43

Analysed by E. Gaul, M.Sc., Frankland Laboratory, Manchester University.

Even if the figures given in the above certificate were not fully attained it would be an immense relief to have a sludge that would dry sufficiently to enable it to be carted, and which was of sufficient value to tempt farmers to fetch it. These two qualities would be enough to secure the process benevolent consideration in every town which has a purification plant and cannot discharge its wastes into the sea.

The fact that the activated sewage process works on exactly the same principles as the percolating filter is in its favour. The process is essentially the same, but it is intensified, and at the same time brought under more control. In the percolating filter the sewage is passed in minute streams or films over stones coated with slimy matter abounding with nitrifying organisms. At the same time the air can gain access to the bacteria to maintain their life. In the activated sludge tank the bacteria in the form of sludge are kept in constant motion in the sewage, rising and falling in countless minute streams, so that there is very intimate contact between them and the organic substances dissolved in the liquid. The circulation is effected by streams of air, which not only keep every particle in motion, but also furnish the oxygen necessary for the life processes of the organisms and for the nitrification of the waste matters in solution. As the process continues these latter become insoluble, and form more sludge, which readily falls to the bottom in a settling tank, leaving a clear, odourless liquid which will not putrify on incubation. In most cases it is not necessary to carry the process to the stage of nitrification. If the albuminoid ammonia is converted into free and saline ammonia, and the liquid is full of dissolved oxygen, it can be safely delivered into a river which is not used as a source of potable water without filtration.

The only material in the process which costs money is the compressed air, and in the early experiments this represented a substantial outlay. Dr. Fowler, in a paper read before the Institute of Sanitary Engineers, put the amount at 14 cub. ft. of free air per cubic foot of sewage, as an average of several installations. Mr. Edward Ardeen, in the discussion, stated that from 4 cub. ft. to 6 cub. ft. of air per square foot of tank area per hour was sufficient to meet the requirements of the fermentation process. At Manchester 15 ft. of free air per hour per square foot of tank area is sufficient for tanks 6 ft. deep. At Worcester 7 cub. ft. of air are used per square foot of surface, including that used by the air lifts, and the cost for air compression by electricity at ½*d.* per unit varies from 32*s.* per 1,000,000 gallons for an outflow of 750,000 gallons per 24 hours, to 12*s.* for an outflow of 2,000,000 gallons. The pressure of the air is between 5 lb. and 10 lb. per square inch.

On the present and opposite pages we give illustrations of an activated sewage plant laid down by Messrs. Jones and Attwood, Limited, of Stourbridge, for treating 30,000 gallons per day at a Government factory. A consideration of the construction of the plant and of the progress of the sewage through it will enable a clearer idea to be gathered of the simplicity of the operations. The raw sewage enters at *a* (Figs. 1 and 2) and flows first through a coarse screen by which all large objects are retained. It then goes into the balance tank *b*, in which the detritus and solid impurities too small to be stopped by the screen are deposited, and the sewage is mixed so as to secure an average strength. The sewage runs into the adjoining sump, from which it is raised by an air lift *c* and *d* and discharged into the disintegration tank *f* by the sewage and sludge downflow pipe *e*. In this tank there are six air pipes extending to the bottom, feeding radial sets of diffusers, and the discharge from these keeps the liquid in such active commotion that all the remaining solids are broken up, and most of them dissolved. Two fine screens *h* admit the sewage from the disintegration tank to the purifying tanks *j*, *j*, in which the course of the liquid is

ACTIVATED SLUDGE PURIFICATION PLANT.

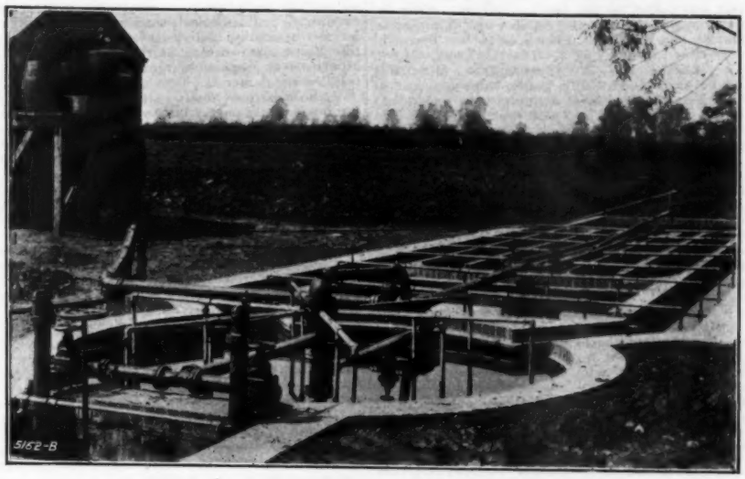


Fig. 3. Tanks with Disintegration Tank in Foreground.

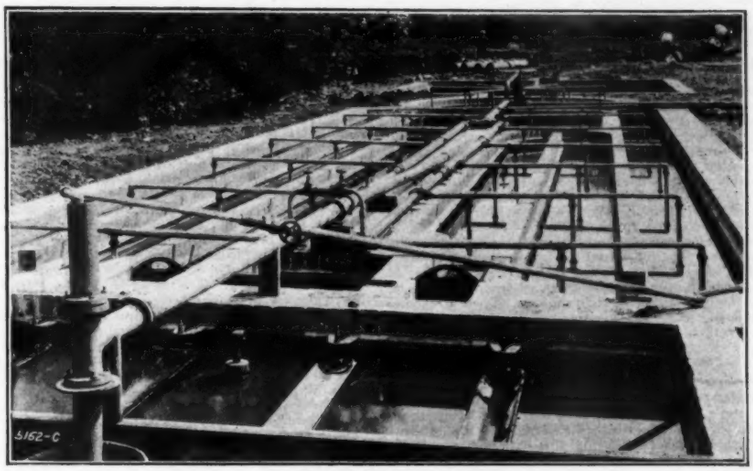


Fig. 4. Tanks with Settling Tank in Foreground.

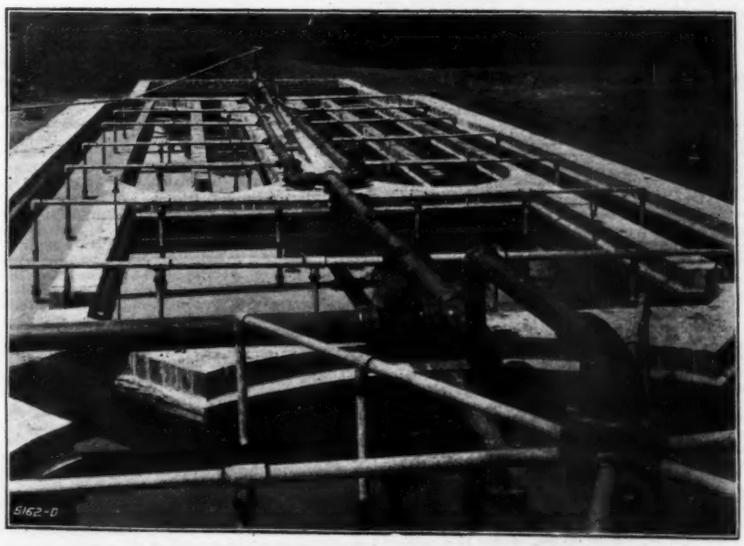


Fig. 5. Tanks showing Air Mains.

indicated by arrows until it flows over weirs and through the pipe *k* into the settlement tank.

An air main runs along the purification tanks, and from this main there are horizontal pipes on each side. From these depend a number of vertical pipes *t*, at the lower extremity of each of which is a diffuser made of porous earthenware through which the air makes its way in extremely fine streams. The diffusers are set on the floor of the tanks in the bottoms of furrows, the purpose of these being to prevent the accumulation of sludge between the diffusers. The sewage makes three passes through the aeration tanks, as shown by the arrows, and then passes through two pipes into the down-pipe *k*, which delivers it constantly into the settlement tank (Fig. 1). The sludge goes to the bottom, while the clear liquid overflows into the four open channels *l*, *l*, and finally escapes to the effluent pipe *w*. The sludge gathers in the sump. Part of it is removed and spread on land to dry, while part is sent back to mingle with the incoming crude sewage. The sludge carries the purifying organisms, and is mixed with the new sewage to the proportion of 25 per cent. It rises up the central pipe in the sump by hydrostatic pressure, and flows into the cell *n*. If any stoppage takes place in this pipe it can be cleared by turning a stream of water through it by the valve *o*. There is an air lift *p* by which the sludge is sent through the pipe *q* into the re-aeration tank, in which it is thoroughly blown with sewage until it overflows through the pipe *r* and the down-pipe *s* into the disintegration tank *f*.

The general appearance of the works is shown in the photographic views, Figs. 3, 4 and 5, on this page. Figs. 3 and 5 are taken from the end at which is the disintegration tank, but do not show the balance tank. Fig. 4 is taken from the opposite end, and shows the settling tank, with weir troughs. It will be seen that the entire plant is quite simple, and is self-contained except as regards the sludge-drying ground. The sewage runs through constantly, coming in raw at one end and flowing off clear at the other, the sludge being deposited, to be partly used again and partly removed.

No rain water is admitted to the plant. In this it is exceptional, for in most places the sewers must take the rainfall as well as the sewage. Then in wet weather the speed of the sewage is, of course, increased, and it receives less aeration. On the other hand, after the first rush the sewage is not so strong, and contains a good deal of dissolved oxygen, so that it is not necessary to carry the purification so far. The wet weather flow is the difficulty in all sewage works. In most it is permitted to deliver all inflow in excess of three times the dry weather flow direct to the watercourse, but this is not altogether desirable. However, we are still in the early stages of the activated sludge process, and further developments may be confidently expected. It is possible that it may be rendered still more active, so that even the wet weather flow may be dealt with in apparatus which is commercially possible. Certainly the process is full of promise, and should undergo rapid extension. It is gratifying to know that in this country we have led the way. The first tank, built at Milwaukee, was designed in the office of Messrs. Jones and Attwood, and was named the Fowler Tank in recognition of the work of Professor G. J. Fowler, D.Sc., of Manchester.

Slag Paving Bricks.—Slag paving bricks, says *The Engineering and Mining Journal*, New York, can be made from almost any class of iron blast-furnace slag for about 6 dols. per 1,000, although saleable for as much as 35 dols. per 1,000. Difficulties in manufacture have now been overcome; the precautions to be adopted arose from the necessity of treating the hot slag as it comes from the furnace, and heating the brick out of contact with air or steam to avoid brittleness.

Signalling on the Pennsylvania Railroad.—The new colour scheme of signal indications, by which white lights will be eliminated altogether, was started on June 28 on all lines of the Pennsylvania Railroad east of Pittsburgh. Nearly a year of preparatory work has been required to make this change possible. Great difficulty was experienced in obtaining deliveries of materials, owing to the war conditions. The decision to eliminate white from the signal colour scheme was reached on account of the increasing use of white lights of various kinds in buildings, drive-ways, roads and streets close or adjacent to the railroad's right-of-way. Under the new plan green will replace white for "clear" or "proceed." "Caution" will be indicated by yellow. Red will mean "stop," as heretofore. In addition to changing the glasses in all the semaphore signals, the following devices have been altered to conform to the new plan of colour indication: marker lights on the rear of passenger and freight trains; switch lamps and targets; markers for track tanks; "slow" signs; "resume speed" signs; and hand lamps at interlocking and block signal stations. No changes have been made in those short portions of the line which are protected by "position light" signals, the longest of which is the electrified section from Philadelphia to Paoli, Pa.

PNEUMERCATOR FOR DETERMINING CONTENTS OF HOLDS.

We illustrate on page 122 an instrument used extensively for determining and indicating the draught of a ship in harbour or at sea, the cubical contents of a ship's hold or of any compartment or vessel containing liquids. It is known as a pneumercator—a word built up of the first syllables of pneumatic and mercury and of the latter part of indicator, compressed air being used to actuate the mercury gauge of the indicator. It is made by the Pneumercator Company, of 118, Liberty-street, New York, U.S.A., and their representative in this country is F. S. Dudgeon, Limited, 30, Great St. Helen's, London, E.C.

The system is very simple and direct in its operation. A balance-chamber, consisting of a bell cast with suitable lug or lugs for attachment, is fixed, in the case of a ship's draught or displacement indicator, in an enclosed casing at predetermined points forward and aft, and sometimes also amidships, below the light load-line of the ship as low down as possible. To this casing there is a 1-in. sea connection. Compressed air is passed into the interior of the balance-chamber, and this is further compressed in direct proportion to the head of water consequent upon the immersion of the ship, and therefore of its draught. There is a connection from each balance-chamber through a ¼-in. copper tubing to a mercury gauge located on the bridge, and thus there is indicated on the gauges, which are suitably calibrated, the draught of the ship forward and aft, the mean draught and also the displacement. By fixing the chamber into a compartment the degree of compression of the air within it accords with the head of the contents, and by using the same connections to gauges suitably calibrated there is indicated the exact contents in any desired notation—inches, feet, cubic feet, gallons, pounds, tons, &c. On the tubing near to the gauge is a three-way valve, so that the air compressor may be connected to the interior of the balance-chamber, or the interior of the balance-chamber to the mercury gauge, or to the atmosphere. This last connection enables the air to be released to bring the gauge to zero, so that on readmission of air the accuracy of the apparatus may be at once checked.

The application of the system to an oil-tank steamer is shown on Fig. 1. In this case there is a draught indicator forward and aft, but not amidships, and the pneumercators are placed on the navigating bridge. In each of the eight tanks or compartments there is a balance-chamber, and the gauges for these are located in the boiler-room, and under the charge of the engineer responsible for loading and discharging the cargo. Fig. 2 shows a balance-chamber, Fig. 3 a single installation ready for fitting on board, and Fig. 4 a typical set showing also the valves for opening the sea connection. In order to give audible and visual warning of a tank being completely emptied or filled the mercury makes or breaks electric connections at the predetermined maximum or minimum, thereby operating an indicator hand and ringing an alarm bell (Fig. 5). Fig. 6 shows the mercury gauge and electrical connections on the back of the indicator board. It will be seen that in the system there are no moving parts to get out of gear. There is an easy check on the operations. The smallness of the tubing enables it to be taken through any alley-way or round any corner.

The displacement indicator is an accurate check on the tonnage of general cargo shipped or of coal bunkered. In cases where cargo has been weighed out the error has proved small to negligence. In one instance the instrument showed 7,248 tons shipped and the cargo when discharged weighed slightly less than 7,249½ tons. The invoices for bunker coal can be checked. Any undisclosed entry of sea water into the ship when at sea is at once noted from the displacement indicator, so that it becomes in such case a safety device. It may be noted that knife-edges can be used for marking maxima and minima. The tank-contents indicator is a still more direct check on the tonnage shipped or discharged.

The pneumercator is also applicable in many ways ashore to measure the depth or head of liquid in reservoirs, canals, wells, tanks, standpipes, &c., the rise and fall of the tide, the head of water over a sill of a graving dock, and for other purposes.

New Industries Established in the United Kingdom.—Since the outbreak of war many new industries have been established in the United Kingdom, and goods which formerly had to be obtained from abroad are now being manufactured at home. The Department of Commercial Intelligence, Board of Trade, desires to make its record of such new industries as complete as possible, in order to satisfy inquiries for new sources of supplies, which are frequently received. Manufacturers are therefore invited to inform the Department of new industries, or new developments of existing industries, established in this country.

SOCIETY OF GLASS TECHNOLOGY.

The July meeting of the above society was held on the 25th ult., in the School of Technology, Manchester. The chair was taken by Mr. Duncan Webb. After the formal business was transacted a paper on "The Action of Chemical and Physical Agents on some Types of Scientific Glassware," by J. D. Cauwood, M.Sc., S. English, M.Sc., and W. E. S. Turner, D.Sc., M.Sc., was read by the last-named. The gradual development of high-class chemical glassware, culminating in the Jena glass of the Schott factory, was first outlined. The importance of chemical glassware in scientific development was emphasised, and it was pointed out that soon after the outbreak of war, chiefly owing to the insistent demands of the Sheffield steel works chemists, steps were taken to promote the manufacture of high-grade chemical ware in this country. Formulæ for making the glasses were placed at the disposal of manufacturers, Professor Jackson at the Institute of Chemistry, Mr. F. W. Branson, of Leeds, and Dr. Travers, of London, taking a leading part in the preliminary work and in the subsequent developments. How well the glass manufacturers had risen to the occasion the results of the paper showed, and they were to be congratulated upon the fact that they had produced glasses as good as, if not better in some respects, than the best German ones.

The method employed in the research had been to subject Jena glass, five new British resistance glasses, and a few chemical glasses made in allied and neutral countries to the following series of tests:—(1) Action of steam; (2) action of boiling water; (3) action of water under a pressure of 10 kg. per square centimetre; (4) action of water at 20 deg. C.; (5) action of water at 80 deg. C.; (6) Action of $\frac{N}{10}$ sodium hydrate solution at 100 deg. C.; (7) action of 2N sodium hydrate solution at 100 deg. C.; (8) action of 2N sodium carbonate solution at 100 deg. C.; (9) action of 5 per cent. ammonium chloride solution at 100 deg. C.; (10) action of boiling 2N ammonia solution; (11) action of hydrochloric acid fumes; (12) action of boiling hydrochloric acid solution; (13) action of 2N sulphuric acid at 100 deg. C.; (14) cracking test.

In addition each glass had been analysed. The results obtained were admirably illustrated by means of lantern diagrams, and it was at once apparent that in every test applied the British glasses compared most favourably with Jena glass, in some of the tests even surpassing it. A very representative collection of the various glasses experimented with was shown, and the effect of the various solvents on the glass surfaces thereby illustrated. A discussion, in which Mr. C. J. Peddle, Mr. Cauwood, Mr. English, Mr. Duncan Webb and Dr. Turner all took part closed the proceedings.

Prior to the meeting a collection of American sands, with their analyses, presented to the society by Professor P. G. H. Boswell, was shown, and also a collection of British sands and glasses manufactured from them. The latter collection was loaned by Messrs. Wood Brothers, of Barnsley. The next meeting of the society will be held in Sheffield during the month of October.

Industrial Restrictions in Germany.—The German War Ministry has recently requisitioned all bar iron, shaped iron and Monier iron. It is prohibited to use these products for new buildings, for extensions and alterations, except where the latter are of urgent necessity, which has to be certified by military authorities. This limitation does not apply to railway bridges nor to current maintenance in the mining industry. Firms using structural bars, iron for ferro-concrete or concrete work have to send in statements as to their stocks on every first day of the month when exceeding 500 kg. in weight; and accurate accounts have to be kept by all concerned.

The South-Western Polytechnic Institute.—The South-Western Polytechnic Institute, Chelsea, S.W. 3, will reopen on September 24, for day and evening courses. The engineering courses include lectures in electrical and mechanical engineering, physics, chemistry, mathematics and practical instruction in the fully equipped laboratories of the Institute. Students are prepared by recognised teachers of the University of London for the B.Sc. degree in engineering of the university, for admission to the various engineering societies, and the examinations of the City and Guilds of London Institute. The evening courses include, besides the engineering courses referred to, classes in aeronautics and electrical installation work.

Breathing Apparatus for Use in Mines.—The Committee of the Privy Council for Scientific and Industrial Research, on the recommendation of their Advisory Council, and at the request of the Home Office, have sanctioned the appointment of a committee with the following terms of reference:—"To inquire into the types of breathing apparatus used in coal mines, and by experiment to determine the advantages, limitations and defects of the several types of apparatus, what improvements in them are possible, whether it is advisable that the types used in mines should be standardised, and to collect evidence bearing on these points. The gentlemen named below have been appointed members of the committee:—Mr. William Walker, Acting Chief Inspector of Mines under the Home Office (chairman); Mr. John Haldane, LL.D., F.R.S.; and Mr. H. Briggs, D.Sc., of the Heriot-Watt College. Mr. A. Richardson has been appointed secretary to the committee, and Dr. Henry Briggs has been constituted director of the inquiry.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

South Yorkshire Coal Trade.—With the possibility of getting supplies by open market sales becoming even more problematical, consumers are urging collieries for the maximum deliveries on contract accounts, and this keeps pits working at the full stretch. Admiralty orders are an important item, and when they have been fulfilled the demands of the works and railways for hard coal absorb practically all that remains available. Larger sorts are particularly strongly held, whilst cobbles are the only smaller sorts furnishing the full tonnage required. Gas coal goes away to inland works as produced, but the output is not large enough to allow of stocks being set aside for the heavy winter reserves which will be required. Slacks meet a steady inquiry, though orders have fallen off somewhat following the holiday season in the Lancashire and Yorkshire mill towns. Cokes have undergone a slight change on the week, and are easier. For household brands the demand continues insistent, though merchants and dealers have wiped off numerous arrears. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—Work in all the shops, factories, forges and furnaces will be continued right up to Friday night, when there will be the customary holiday cessation. From four to ten days, according to the nature of the orders on hand, the holiday will extend, though the longer stoppage in some cases has been rendered imperative by the need for overhauling and repairing plant, which has run uncommonly well under the excessive strain. The advent of this interval has quietened down the buying and selling of all classes of material, and some works are advising the suspension of the delivery of materials to their establishments for a week from to-day. The general opinion here is that the holiday will more than pay for itself by rehabilitating the health and spirits of the workers, which the extreme heat has affected. Steel production in hot summer weather is not an ideal task, and the authorities have intimated that the rest has been well earned by the exceedingly good output maintained under trying conditions. The demand for all grades of steel, especially semi-manufactured, has reached an abnormally high figure, and the prospect facing the workers when they resume is one requiring stern, unbending endeavour. Aeroplane orders, or rather steel for their construction, are growing proportionately greater week after week. Tools of all descriptions are urgently wanted. The problem of rolling-stock replenishment, renewals and repairs is under consideration. The needs of the Army in France absorb almost the whole present-day limited production. Tyres, springs and axles for renewal purposes are wanted, but the day is approaching when the economical policy of to-day will necessitate remoulding. Sheep-shear makers have had a very busy season since last autumn, and orders have been very large for the Argentine and Australia. Overseas orders have arrived with the latest mails for files, tools, saws, plane irons, machetes, shovels, picks, hammers, cutlery, plate, hardware and steel.

Sheffield Trade Matters.—The annual meeting of the Tinsley Rolling Mills Company, Limited, was held at Sheffield on Monday, when a dividend at the rate of 10*s.* per share on the ordinary shares was declared, 1,000*l.* added to the reserve, and 5,742*l.* 7*s.* 6*d.* carried forward. It was stated that the past twelve months had been full of activity and difficulty.

The Automobile Association and Motor Union.—The annual general meeting of the Automobile Association and Motor Union was held on July 25 at the Savoy Hotel. Mr. W. Joynson-Hicks, M.P., chairman of the association, presided. In the course of his remarks, and with regard to petrol supplies, he stated that motorists had been reduced from 16 gallons to 10 gallons per month, and from 10 gallons to no gallons per month, unless they were doing war work. Personally he did not complain. He had given up his car and chauffeur some time back, and had no use for petrol. They all intended to win this war, and were willing to suffer in their private capacities in order that petrol might be used for more important purposes. There was ample petrol in the world, and there would be no shortage when the war was over. The Shell Company had 18,000,000 gallons of petrol stored waiting to come to this country when the war was over and tankage was available. He therefore hoped that motorists would realise that petrol prices would go down when the war was over. He quoted figures showing that a surplus of 6,000,000 gallons of petrol had been collected by imports during the first five months of this year, as against the corresponding period of last year. He thought they were entitled to ask their friends in the Services to do everything possible to avoid waste of petrol. Last year he spoke very strongly on this subject. This year he found that much of the waste then complained of had been stopped. Furthermore, the military authorities had appointed an inspector of petrol, but he certainly thought that there were opportunities for the equivalent of "petrol control" of the naval and military vehicles travelling round the country. The members, he added, should assist in the revival of the manufacture of motor vehicles. After the war they would have new motor engines and cars far more wonderful than those in use before the war.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Although in certain quarters some absolutely unavoidable delay took place in the completion of the necessary repair work carried through during the holidays, the way in which labour in the steel works was resumed last week was a great tribute to the patriotism of those employed there. A busy time lies in front of all engaged in the production of steel, for there is no falling-off in the Government orders for all classes of material—indeed, rather is there a decided increase in the demand for material required for the prosecution of the war. This is further limiting the supplies available for other purposes, and it is now firmly borne in upon steel makers in the West of Scotland that there is little possibility of their being able to execute any general orders, so necessary is it that they should conserve the entire production for Government use. Contributing also to this state of affairs is an increasing shortage of steel. Large quantities are still being utilised in the shipyards, where the work placed by the Shipping Controller proceeds with much activity, the precision with which supplies are being delivered enabling the work to be carried on with the utmost despatch.

Malleable Iron Trade.—The repairs undertaken during the holidays having now been satisfactorily completed, the production of malleable iron in large volume is again being proceeded with, and the activity is intense. Makers have as many orders on hand as will keep their workers fully occupied for some considerable time ahead, Government demands, naturally, monopolising the bulk of the output. Although it is expected that the repairs executed should make an increased output possible, it is not very clear yet whether the ordinary mercantile consumer will benefit to any appreciable extent.

Scotch Pig-Iron Trade.—Pig-iron continues in such constant demand that, at times, it is difficult to obtain supplies of some brands, foundry No. 1 particularly. Hematite is much in request at the steel works engaged in naval and military work; while at the iron works there is an equally intense demand for forge iron. Very little ordinary mercantile trade is being put through in the meantime. Where not officially fixed prices are firm with a strong upward tendency.

CITY AND GUILDS OF LONDON INSTITUTE.—The Department of Technology of the City and Guilds of London Institute, Exhibition-road, London, S.W. 7, have now issued their programme for the session 1917–18. It is published at the price of 9*d.* net, by John Murray, Albemarle-street, S.W. 1. It covers over 80 technological subjects in which examinations are held. The book contains over 400 pages of regulations for the registration, conduct and inspection of classes and examination of candidates, and for the award of teachers' certificates in manual training and in the subjects dealt with.

DIRIGIBLE BALLOONS FOR THE POSTAL SERVICE.—The French journal, *La Nature*, contemplates the use in the near future of dirigible balloons for the carriage of mails. They could, for example, fly in a straight line from Ireland to Canada or Newfoundland in less than 36 hours. The cost of the machine complete would probably be 10,000,000 francs (400,000*l.*). To this should be added the cost of maintenance, the cost of the shed, the salaries of the personnel, the cost of the liquid fuel, &c., the whole making a heavy total. But the gain on the time for the delivery of mails would be worth an extra postage fee; taking the postage at 2 francs and on the basis of 200,000 letters carried on each trip, the receipts for each trip would amount to 400,000 francs. (16,000*l.*). On the estimation that a dirigible could make a total of 50 journeys each way, 100 in all, its gross receipts would amount to 1,600,000*l.* If, says our contemporary, the cost of the machine be reckoned, as above, at 400,000*l.*, and the cost of working over the 100 journeys be estimated to reach an equal sum, there would remain 800,000*l.* as gross profits for the pioneer transatlantic company.

LONDON COUNTY COUNCIL EDUCATION COMMITTEE—MUNITIONS.—We have received from the Education Committee of the London County Council an extract from the agenda paper giving a short statement of the work accomplished during the past two years. Very soon after the formation of the Ministry of Munitions, efforts were made to utilise the educational resources of the London technical institutes to the fullest extent on munitions. The demand for training students did not tax the whole energies of the Council's organisation, and it was decided to detail skilled staff from other branches of the service into certain institutions which could take up the manufacture of gauges, this line being urgently called for at the time by the Ministry of Munitions; it has been possible to develop this work to a remarkable degree by the utilisation of these skilled workers, and this has been done with comparatively little interference with the normal activities in technical education. With the special object of avoiding interference with ordinary educational work, the training centres for munitions students were placed at Brixton and Shoreditch, where engineering instruction is not ordinarily given, and these centres were equipped with machines drawn from handicraft centres, and with more modern tools supplied by the Ministry of Munitions. During the two years ended June 30, 1917, as many as 8,089 students have been under training in the various centres, of whom 6,088 have been certificated as satisfactorily completing their training; 5,751 of these are known to have obtained employment on work of national importance.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—As was anticipated, August allocations of Cleveland pig-iron are on a very liberal scale, there being no dearth of iron, and brisk home trade is now passing. Applications from Scotland are very heavy after the holidays there, but, on the other hand, requirements of North of England foundries are slightly below the average of the last few months, due to holidays to be observed during August. There is a keen continental demand, and with rather more tonnage coming forward some expansion of foreign trade is looked for. Prices keep steady and firm. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*: and for shipment to France and to Italy No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

Hematite Iron.—There is still much stringency in the East Coast hematite branch of trade, but careful distribution, under strict official supervision, continues to assure regular and adequate supplies to customers accessible by rail, and to leave some little surplus for export sale. A few home transactions are recorded from time to time, but new foreign business is very difficult to put through, and export quotations are almost nominal. Under old contracts, however, loadings for our Allies are receiving as prompt attention as circumstances permit, and, under conditions prevailing, dispatches may be regarded as satisfactory. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France and 142*s.* 6*d.* for export to Italy.

Manufactured Iron and Steel.—There is absence of new features in the finished iron and steel industries. The heavy Government requirements and the large needs of the shipyards continue to absorb almost the whole of the output, so that there is very little material available for sale in the ordinary way of business. Prices are firm. To home customers common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Coke.—The more than ample supply of coke has no apparent weakening influence on values. Local demand is heavy, and descriptions needed for the blast-furnaces still realise fixed maximum rates, average kinds selling at 28*s.* at the ovens, and low phosphorus sorts at 30*s.* 6*d.* at the ovens.

Ironworkers' Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England have certified the average net selling price of iron rails, plates, bars and angles for the two months ended June 30 last at 13*l.* 10*s.* 9.87*d.*, as compared with 13*l.* 9*s.* for the previous two months, and under sliding-scale arrangements ironworkers' wages for August and September will be the same as prevailed during the preceding two months.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Conditions on the coal market this week are unchanged. The Admiralty collieries are fairly well supplied with requisitioned tonnage, but other pits are not so well off. The dearth of business seems to be greater than ever, and members are utterly wearied with the prevailing conditions. Offices engaged in the work of the Controller or the Admiralty are the only centres of activity, and in their activities there is more restraint than there is encouragement of trade. Current values possess no interest, but there is a growing disinclination to observe the conditions of the Controller's fixed-price scheme, and an interesting situation may probably arise if and when the supply of tonnage becomes normal again. The inexplicable delay in announcing the classification of Welsh coals is adding to the difficulty. As suggested last week, pitwood is inclined to be easier, and is at about 58*s.* 6*d.* to 60*s.* per ton.

Newport.—The market this week is again featureless. There is no improvement to report in the supply of tonnage, and only a comparatively small number of tips have been at work at the Alexandra Docks. Hardly any parcels of coal are changing hands, and there is little prospect of any business till after the holidays.

Miners' Wages.—At a meeting of the owners' representatives on the Conciliation Board for the Welsh Coal Trade a report was received from the joint accountants giving the result of the audit of the selling prices for the three months ended June 30 last. This is the third taken since last September and, like the two previous audits, showed a reduction in the average prices compared with those in the September quarter of 1916. On the ground of this reduction in price and the increased and continuously increasing cost of production, it was decided, subject to the approval of the Controller of Mines, to apply to the workmen's representatives for a reduction of 30 per cent. in the general wage rate. This decision was formally communicated to the Controller, who, however, has replied this week stating that no application for a reduction in the general wage rate should be made at present. While abiding by this decision, the owners draw attention to the fact that in February last, as now, they were entitled to a reduction in the general wage rate, owing to the fall in the average selling prices of coal—and this is the main factor in the regulation of wages under the Conciliation Board agreement entered into as the result of Government intervention last year—without taking into account at all the heavy increased cost of working. It is only, therefore, at the direct request of the Controller that they have once more refrained from applying for a reduction in the general wage rate, and this course is followed without prejudice to their future position.

NEW SHIPYARD IN NORWAY.—The well-known Aker Engineering Company is about to start shipbuilding on a somewhat large scale. The site is located in the neighbourhood of Christiania, and the Norwegian engineer, Mr. Aamundsen, who for a number of years has occupied a leading position at the Burmeister and Wain yard, Copenhagen, has been engaged as director of the new concern.

THE PORT OF GOOLE.—In the article in our issue of the 20th inst. on the "Lancashire and Yorkshire Railway Shipping Shed at Goole" it is stated that the principal entrance locks are 460 ft. in length and 22 ft. in width. These figures are incorrect. The correct particulars of the large entrance locks at Goole are as follow: Victoria Lock, 500 ft. in length, 47 ft. in width; Ouse Lock, 264 ft. in length, 58 ft. in width.

THE ENGINEER IN COMMERCE AND INDUSTRY.—In Denmark a new section has just been formed within the Union of Danish Engineers, with a view to securing the co-operation of engineers for the advancement of Danish industry and of the commercial undertakings which it entails. This section will embrace all technical branches, but it will differ from the other sections by also comprising general industrial and mercantile aspects, in close touch with the doings of the day. The scheme is being backed by a number of eminent engineers.

POST-WAR TRADE WITH BELGIUM.—His Majesty's Government have appointed a committee to investigate the means of production and advancement of trade and commerce between the British Empire and Belgium. The members of the committee, representing the Foreign Office, Board of Trade, and the commercial community, are as follow:—Representing the Foreign Office: Sir Cecil Hertslet (chairman of the committee), His Majesty's Consul-General for Belgium; Mr. R. Macleay, Counsellor of Embassy in the Diplomatic Service, Deputy Controller of the Foreign Trade Department, Foreign Office; Mr. M. Neville Kearney (secretary of the committee), of the Consular Service, attached to the Foreign Office. Representing the Board of Trade: Sir W. H. Clark, K.C.S.I., C.M.G., Comptroller-General of the Department of Commercial Intelligence, Board of Trade; Sir E. Wyldbore-Smith, Director of the Commission Internationale de Ravitaillement; Mr. Percy Ashley, Board of Trade. Representing British commercial and financial interests: Sir Algernon F. Firth, Bart., representing the Association of Chambers of Commerce of the United Kingdom; Mr. E. F. Oldham, representing the Federation of British Industries; Mr. M. Cleminson, representing the Chamber of Shipping of the United Kingdom and the Liverpool Steamship Owners' Association; Sir R. Vassar-Smith, Bart. (chairman of the Committee of London Clearing Bankers), representing the Bankers' Clearing House; The Lord Faringdon, representing the British Trade Corporation; Mr. Frank Potter (general manager, Great Western Railway), representing the Railway Executive Committee. The members of the committee (other than those representing the Foreign Office and Board of Trade) have been nominated by the bodies which they represent, at the invitation of His Majesty's Government. The following are the terms of reference for the committee:—(1) This committee is established for the purpose of inquiring into all matters relative to trade between the British Empire and Belgium, with a view to increase and develop that trade by every desirable means. (2) It will be the duty of the committee to investigate, as far as possible, all means to be adopted in order to attain the object set out in paragraph 1. The committee will examine into the supplies and requirements of the respective countries (in so far as they have relation to its scope) and give advice as to how trade between them can best be established, developed and increased. It will obtain information and evidence from all available sources, and endeavour to render all possible assistance in regard to shipping, manufactures, imports and exports, and trade generally between the Empire and Kingdom. (3) The committee will consist of three representatives appointed by the Foreign Office, and three representatives appointed by the Board of Trade. A chairman and secretary will be chosen from their number. The committee shall have power to add to its numbers by the appointment of such persons of experience in the matters with which it has to deal as it may think expedient, and it will also consult from time to time other representatives of commerce having special knowledge of Belgian trade, shipping and finance. (4) It is particularly laid down that the purpose of this committee shall be a general one, and that it shall not be part of its duties to foster the advancement of the trade of any particular individual or firm, nor to devote its assistance to any special branch of trade or industry except in relation to the general principles for which it is established. The committee will be known by the short title of "The Belgian Trade Committee." An office of the committee (under the Foreign Office) has been established provisionally at 39, Parliament-street, S.W. 1, to which all communications for the committee should be addressed.

THE PNEUMERCATOR FOR INDICATING THE LEVEL OF FLUID FOR SHIPS' TANKS.

(*For Description, see Page* 120.)

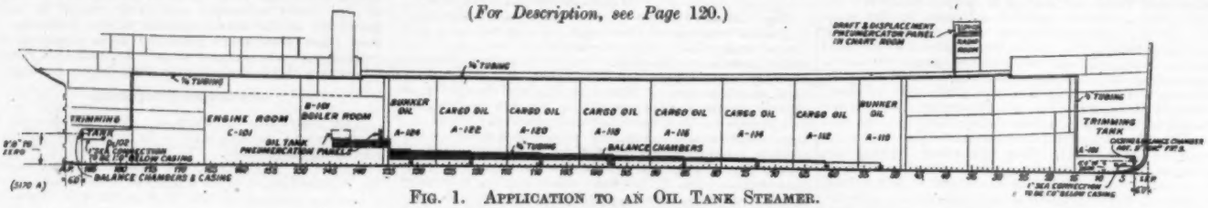


Fig. 1. Application to an Oil Tank Steamer.

Fig. 2. The Balance Chamber.

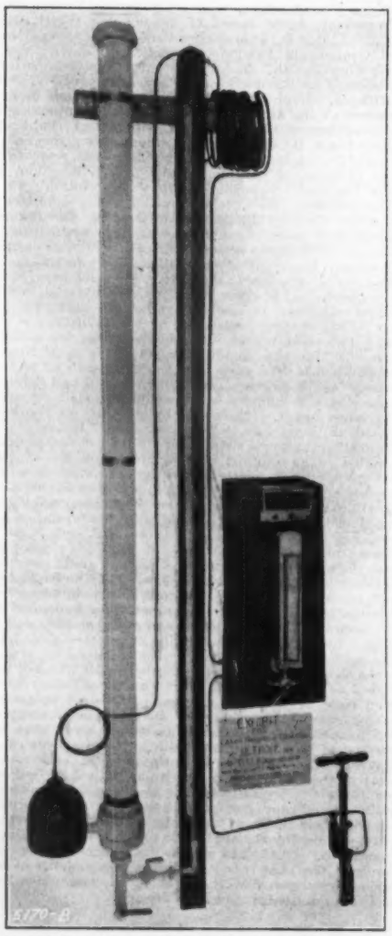


Fig. 3. A Single Installation.

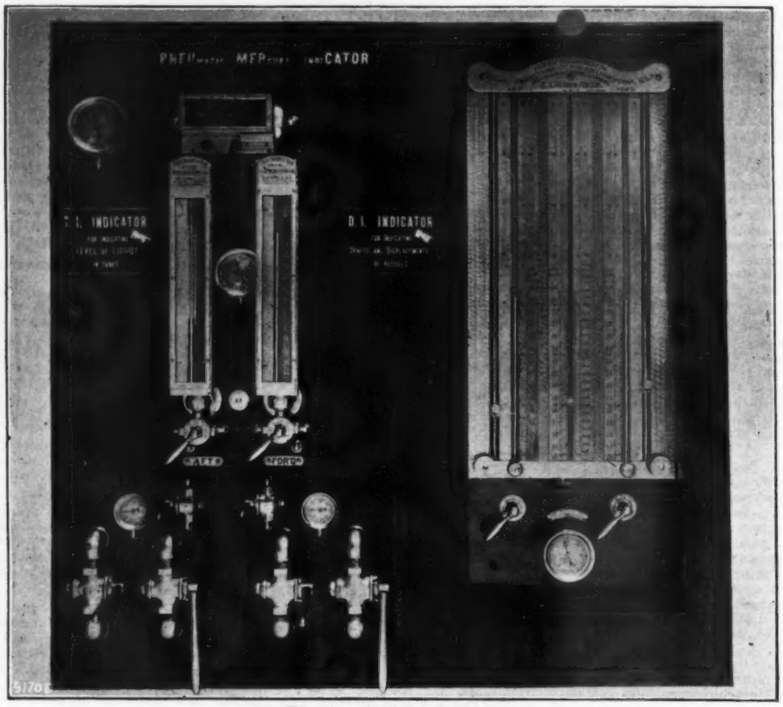


Fig. 4. A Typical Set.

Fig. 5. Warning Bells.

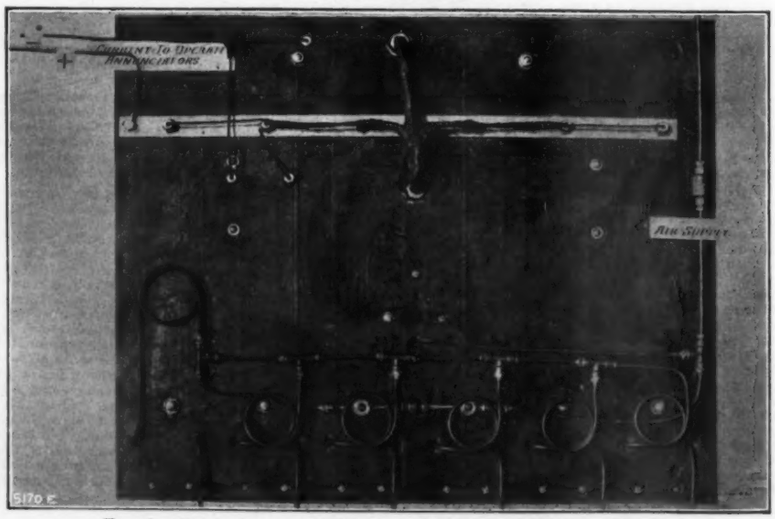


Fig. 6. Connections for Mercury Gauges and Warning Bells.

WOODALL-DUCKHAM VERTICAL RETORTS AT THE EXTENSION WORKS

MR. A. E. BROADBERRY, M. INST. C.E., CHIEF ENGINEER;

(For Description, Page

Fig. 62.

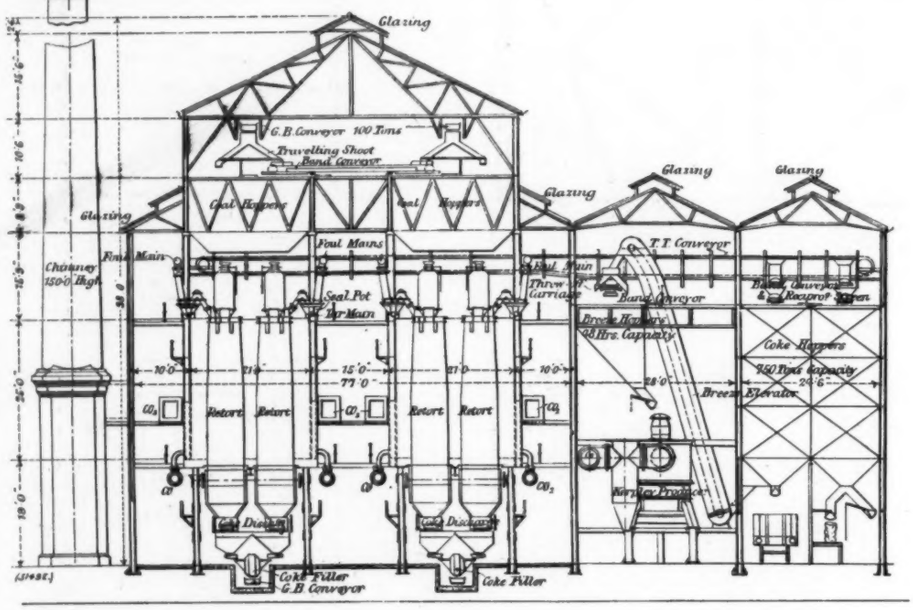


Fig. 64.

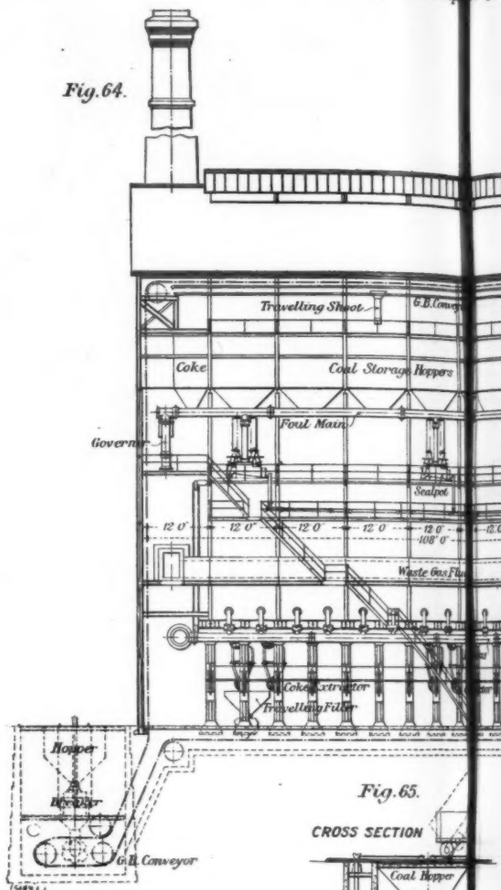


Fig. 65.

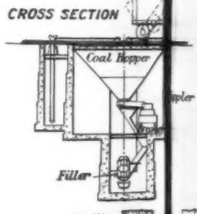


Fig. 63.

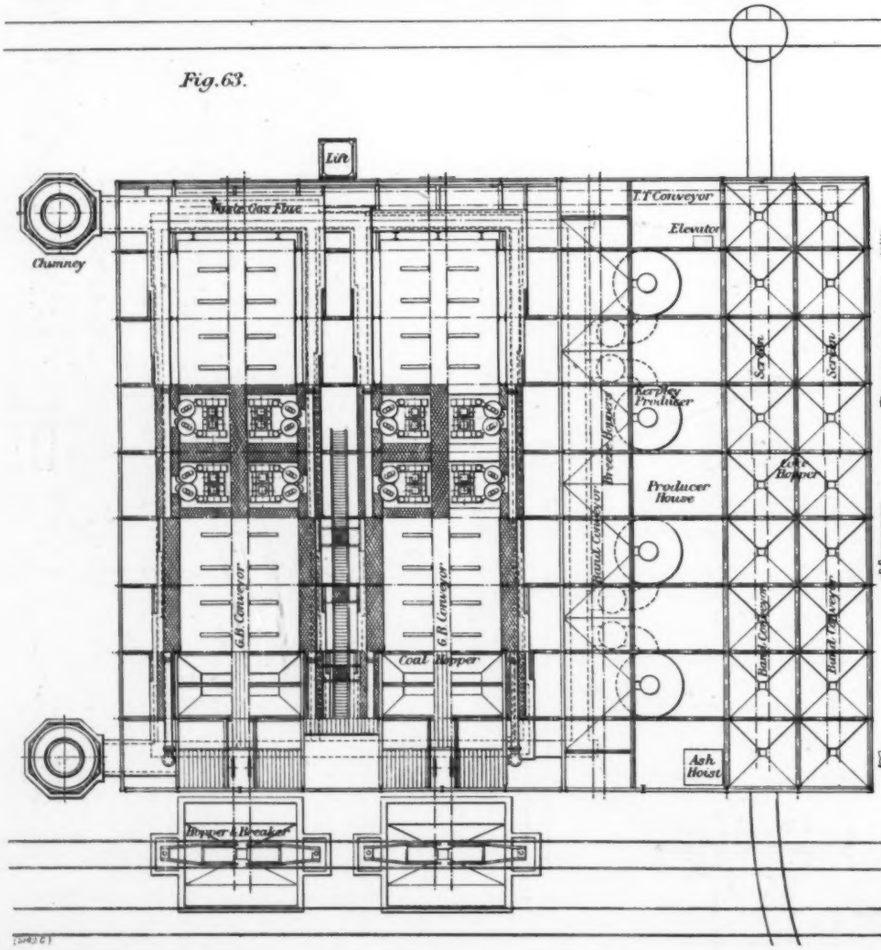
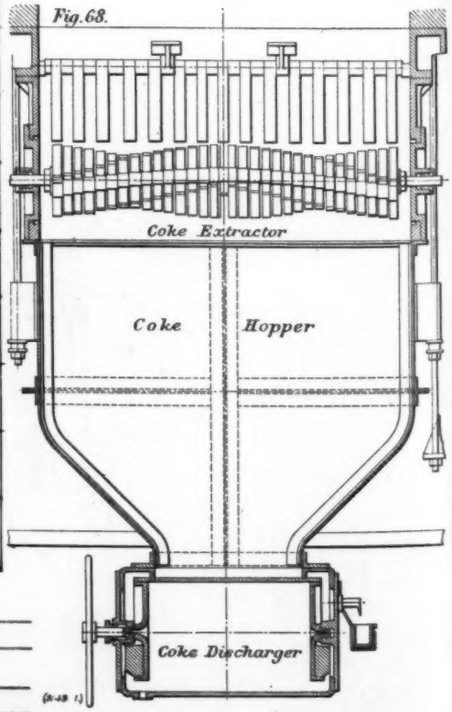


Fig. 68.



ORKS OF THE TOTTENHAM DISTRICT LIGHT, HEAT AND POWER COMPANY.

NEER; WOODALL-DUCKHAM COMPANY, WESTMINSTER, CONTRACTORS.

(For Description, Page 113.)

Fig. 66. CROSS SECTION.

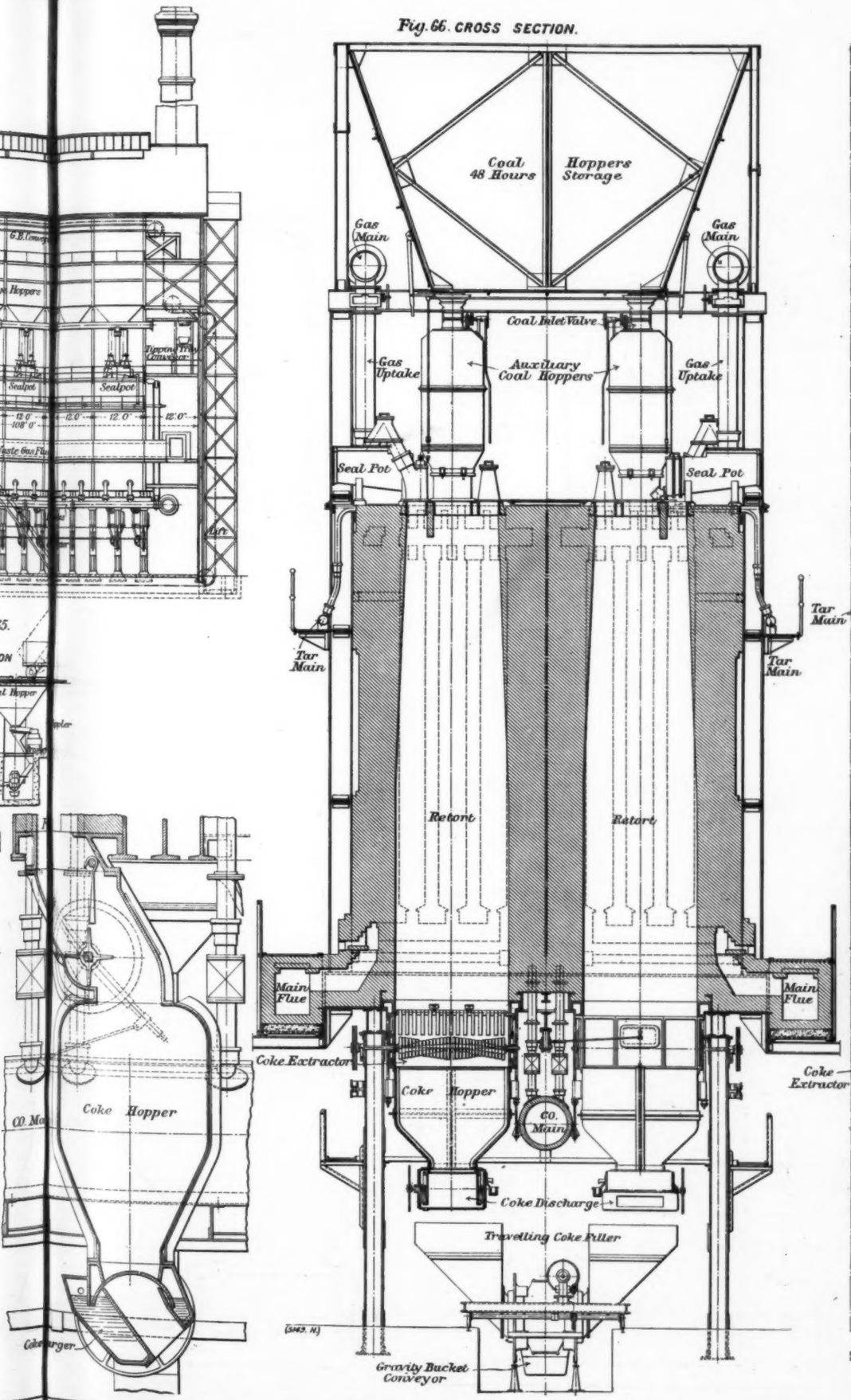
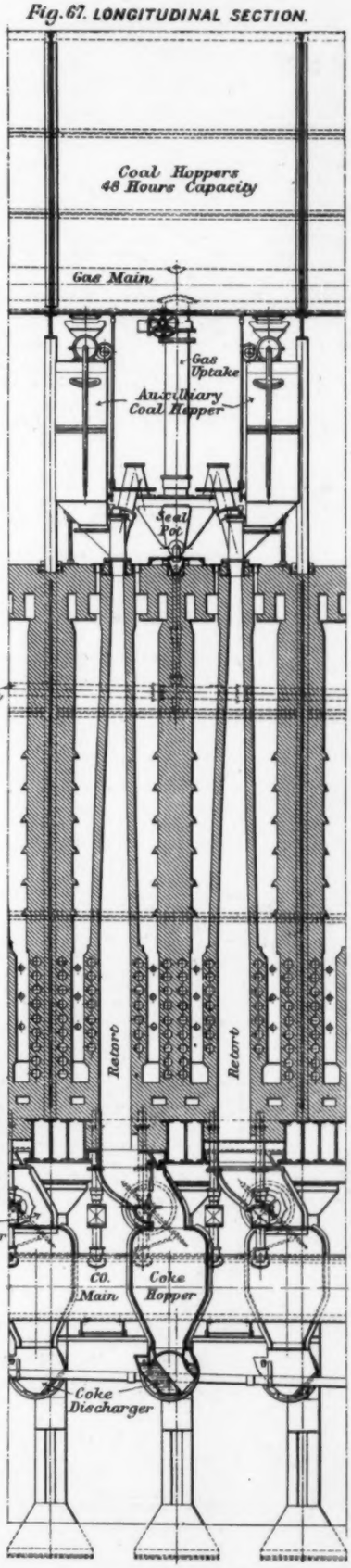


Fig. 67. LONGITUDINAL SECTION.



AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia, Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaughnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12 Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Subscriptions and Advertisements, Librarie B. Tignol, 53bis, Quai des Grands-Augustins, Paris. Also for Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Longstreet.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 957-958, Monadnock Block.
For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2 4 6
For Canada—	
Thin paper copies	£2 0 6
Thick " "	£2 5 0
For all other places abroad—	
Thin paper copies	£2 5 0
Thick " "	£2 9 6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3683 and 8598 GERRARD.

CONTENTS.

	PAGE
Stresses in Rotating Discs with a Hole in the Centre (*Illus.*)	109
Industrial Councils and the Garton Memorandum.—No. I.	112
The Extension of the Tottenham District Light, Heat and Power Company's Works (*Illus.*)	113
Industrial Notes	116
Ascertaining the Centre of Gravity Common to Several Weights	117
Corrosion of Condenser Tubes	117
Activated Sludge Sewage Purification Plant near Worcester (*Illus.*)	118
Pneumercator for Determining Contents of Holds (*Illus.*)	120
The Society of Glass Technology	120
Notes from South Yorkshire	120
Notes from the North	121
Notes from Cleveland and the Northern Counties	121
Notes from the South-West	121
American Shipping and Shipbuilding	123
Some High-Pressure Phenomena	124
Peat Powder Fuel for the Swedish State Railways	125
Notes	126
The Railway Problem	127
Tungsten Ores	128
Colonial Engineering Projects	130
Diagrams of Three Months' Fluctuations in the Prices of Metals	130
The Moline Farm Tractor (*Illus.*)	131
Military Influence on Motor Truck Design	131
The Society of Chemical Industry (*Illus.*)	133
Catalogues	134
ENGINEERING Patent Record (*Illus.*)	135

With a Two-Page Plate of the WOODALL-DUCKHAM VERTICAL RETORTS AT THE EXTENSION WORKS OF THE TOTTENHAM DISTRICT LIGHT, HEAT AND POWER COMPANY.

NOTICE OF MEETING.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, August 4, in the Wood Memorial Hall, Newcastle-upon-Tyne, at 2 o'clock. The following papers will be open for discussion:—"Further Notes on Safety-Lamps," by Mr. Simon Tate; "Some Practical Notes on the Use of Timber in Coal-Mines," by Mr. F. C. Lee, M.A. (Chin.), B.Sc.; "The Horsley and Nicholson Automatic Compound Syphon," by Mr. George R. Nicholson, F.I.I. The following paper will be read or taken as read:—"Little Namaqualand and its Possibilities as a Copper-Producing Country," by Mr. F. W. Jenkins.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, AUGUST 3, 1917.

AMERICAN SHIPPING AND SHIPBUILDING.

SINCE the war started 37,000,000*l.* of new capital has been invested in United States shipping enterprise; a Federal shipping board has been appointed, under the terms of the Ship Purchase Act, which was passed by Congress last session, and has been authorised to raise capital stock up to 30,000,000*l.* to acquire and operate ships, whilst a proposal is before the House of Representatives for the expenditure of 150,000,000*l.* for the construction of merchant vessels; more than 1,000,000*l.* has been voted for improvements and additions at the navy yards. Tens of millions of new capital are being invested in private shipyards.

This great boom in American shipbuilding and its twin industry, shipping, is of more than temporary and more than ordinary interest. It may be that, after the war, the United States instead of Germany will be our chief rival in the shipbuilding and ocean-carrying trades, as that country was in the first half of the nineteenth century. The Americans are playing a highly welcome part in helping to make good the shipping losses due to the German submarines, and in helping to combat the submarine menace. But the great activity in American shipbuilding is something more than a creation of the war. Certainly it has been accelerated by the war; but it is part of a national movement, inaugurated before this world upheaval, to revive permanently the shipping and shipbuilding trades of the United States. A vast avenue of international trading and competitive possibilities is opened out by American shipping legislation and enterprise, coupled with the opening of the Panama Canal—assuming that the new waterway proves safe and successful.

American shipping has had two generations of progress, followed by two generations of retrogression. Now history seems to be repeating itself. The trade seems to be taking another new lease of life. Between 1790 and 1850 American shipping was raised from a very low to a very high position. In the 'fifties of the last century the American flag was in every port, and United States builders launched 50 per cent. more new tonnage than we did. It was not, indeed, until the 'seventies that Great Britain built as large a tonnage in a year as the United States built in the 'fifties. The first Federal Government, in its first Act for the protection of home industries, enacted a special set of laws, dues and customs designed to foster shipping and shipbuilding. At that time the situation relatively was pretty much the same as it has been in recent years. In 1790 the gross tonnage of United States ocean-going shipping was only 123,000 tons. Of the imports and exports 90 per cent. was carried in foreign vessels—80 per cent. in British ships. But under the laws enacted in 1789 United States shipping grew to a tonnage of 1,000,000 tons by 1820, and the proportion of the country's commerce carried in home vessels reached 90 per cent. British and other foreign ships were squeezed out of American trade as fast as American ships could be launched. The shipping favours were continued—variously in the form of subsidies for home vessels or home shipbuilding, discriminatory customs tariffs and harbour dues against foreign vessels—and by 1855 United States ocean tonnage reached 2,500,000 tons.

In the 'fifties, however, the American agricultural interests set up a vigorous opposition to the shipping subsidies, and by 1862 all the favours were withdrawn, and the shipping trade of the United States was left to compete with the world unaided. A decline at once commenced, and by 1910 the United States ocean-going tonnage had shrunk to 1,000,000 tons, against Britain's 15,000,000 tons and Germany's 4,000,000 tons. That was in spite of a huge growth in the population and commerce of the United States. In the last twelve months before the European War only 8 per cent. of American external commerce was carried in American ships. The substitution of iron and steel for wood in shipbuilding was, of course, one factor in the decline of American shipping. The United States is exceedingly rich in iron ore and coal, and its iron and steel producing capacity is now bigger than that of Britain and Germany put together; but when it comes to shipbuilding our American rivals labour under marked disadvantages. Their ore is deposited 1,000 miles from their coalfields; their steel works, on account of the coal, are between 400 miles and 500 miles from seaboard, whilst their wages are extravagant for only moderately skilled workmen. The latter point, of course, is due to the abnormally high standard of living and the keen demand for labour, consequent on the phenomenal industrial development of the United States internally. The chief factor, however, in the decline of American shipping since the middle of the last century was the withdrawal of the subsidies and other favours just mentioned.

For several years there has been a steady agitation in America for more ships. About twenty years ago a Merchant Marine League was formed to advocate a revival of United States' shipping. Several shipping measures were introduced from time to time, but none of them passed, though Congress votes showed a steady growth in favour of the "more ships" movement. However, the almost simultaneous opening of the Panama Canal and the outbreak of the world war have combined to bring this question right into the forefront of American politics. The United States Government carried a notable measure entitled the Ship Registry Act in 1914, which permitted, on certain terms, the transference of foreign-built vessels to the American flag; and last year it enacted what is still called the Ship Purchase Bill, providing for the appointment of the Federal Shipping Board, above mentioned, and the acquisition and operation of merchant ships by the Government, whilst further measures are promised. The confidence that is felt in the permanency of the American shipping revival is evidenced by the large amounts of new capital that are being invested both in shipbuilding yards and ships. When the war broke out the tonnage of United States shipping engaged in foreign trade was only, in round figures, 1,000,000 tons gross. An interesting feature of current developments is the revival of wood as a building material,* partly on account of the famine price of steel, and partly in consideration of the urgent demand for rapid construction. At the beginning of the year 161 wooden vessels of 500 tons gross or more were being built, or were under contract, in the United States. But that this revival of wood is likely to be permanent is more than doubtful.

Whether the general revival will be more than temporary—whether it will outlast the war conditions—is a question of open controversy. Much will depend upon the measure of State support, or protection, the United States Government will give

* See ENGINEERING, vol. ciii, p. 442, and p. 90 *ante*.

shipping to enable it to compete with countries that have cheaper building resources and cheaper seamen than America can ever hope to have. Much also will depend upon the attitude and policy of our British workmen, engineers and statesmen. If our trade unionists are unreasonable after the war, if our engineers will not adopt standardisation and other economical methods, and if our statesmen will not give enterprise and industry the best possible consideration, then there will be nothing to prevent such a growth of American shipping and shipbuilding, and such a decline of the British trades, as will eventually transfer supremacy in these lines from this country to the United States. On the other hand, we hold such unique advantages —with our coal and iron supplies, our steel works and shipbuilding yards and shipping ports all practically side by side, and with our huge building capacity and inherent skill—that we ought, without much difficulty, to hold our own against any possible competitor. This brings us to the root question of competition—the question of cost. The whole problem resolves itself into one of cost. The country that can produce and work ships the most cheaply will get the most trade.

How formidable the task of resuscitating American shipping will prove—or would have proved, but for the war—may be gathered from the fact that, according to the calculations of the National Trade Convention, a tramp steamer costing 66,000*l.* in England, in 1913, would have cost 138,000*l.* in the United States, whilst the expense of sailing was 80*l.* per month for wages, and 20*l.* for stores, food, &c., in favour of the British flag. Such examples as the following are given: ss. Aztec, gross tonnage 3,508, operating between San Francisco and Hong-Kong (United States flag), total monthly wages 2,695 dols.; ss. Canterbury (British), 3,508 tons, operating between London and the Pacific Coast, monthly wages 901 dols.; ss. Titania (Norwegian), 3,613 tons, operating as a tramp on the Pacific Ocean, monthly wages 614 dols. It was pointed out that American vessels of more than 1,000 tons must carry a third mate whether they needed him or not, and must have four quartermasters, although English ships carried only two and let seamen stand the other watches; that American ships must carry four licensed engineers, whilst most foreign vessels carried only three, the donkeyman standing the other watch. American ships require three water-tenders, a rating unknown on foreign vessels, and a large number of ordinary seamen, whilst there were enormous differences in the wage scales.

At the National Foreign Trade Council Convention this year estimates were submitted showing that the average wages in shipbuilding in Great Britain were 50 per cent. less, and the net output per worker 14 per cent. higher than in American yards. Mr. J. W. Powell, president of the Fore River Shipbuilding Corporation, contended that in spite of the vast capital expenditure devoted to the improvement of American shipbuilding plants during the past three years, which was believed to have placed them in the front rank from the point of view of equipment, no superiority of design or methods of building could overcome the basic disadvantages of the American industry. Only legislative enactments could enable the United States to compete successfully under peace conditions with other nations, in view of the cost of materials and labour.

Other high American authorities hold different views. The capital that is being risked in American shipping and shipbuilding is proof of the confidence felt in the future. It is believed that on the one hand the United States Government will grant such generous assistance, by way of subsidies or other measures, whilst on the other hand the war and labour demands will so enhance British costs as to render shipping and shipbuilding profitable even in America. The *New York Annalist*, in summing up the possibilities a few months ago, declared that "it was probable that for many years to come the cost of labour and materials in the United Kingdom and Germany would be as high as in the United States, and that the start which American yards had obtained, thanks to the war, would enable them to compete successfully with foreign shipbuilders." But with our coal and iron supplies, our steel works and shipbuilding yards and ports, all practically side by side; with our peculiar skill and aptitude in shipbuilding and seafaring; with our huge imports of food and raw materials, and equally abnormal exports of manufactures; with vast Colonies and great Allies prepared to give us practical trading preferences and to boycott our erstwhile greatest rivals, the Germans, we only need active and hearty co-operation between labour and capital and the State to keep us ahead of all nations in shipping. But such co-operation we must have, or fail in the international race.

SOME HIGH-PRESSURE PHENOMENA.

The older generation of the present day has had to learn a great deal since leaving college, and has had to unlearn a good deal as well. The indestructibility of the atom has gone, to be resuscitated in a new sense; the discredited emission theory of light has come to honour again; our notions of transparency have been revolutionised; one permanent gas after another has had to submit to liquefaction; and the incompressibility of liquids is no longer an orthodox tenet. When liquids and solids were exposed to pressures and temperatures of thousands of atmospheres and degrees, scientists recognised that their admitted ignorance of the nature of liquids and solids was greater and their knowledge far more defective and faulty than had been assumed. Materials had been too much judged by what they appear to be at ordinary temperatures. But the study of extreme conditions, low and high, promised to simplify our views. Life and complexity seemed, and seem, to be impossible under extreme conditions; many differences appeared to vanish as absolute zero or very high pressures were approached, and it looked as if the liquid molecule would become too closely packed at high pressure to admit of much variety, at any rate as to compressibility and thermal expansion. Those anticipations have not been realised. Liquids seem to retain their physical peculiarities at 20,000 atmospheres, and the assumptions concerning the processes going on in the interior of the earth remain as speculative as they were. One general conclusion may perhaps be drawn. On the whole, rise of temperature and rise of pressure have analogous effects. That temperature is the more powerful agent, apparently, and that a rise of 10 deg. may be said to correspond to a pressure rise of 1,000 atmospheres, is largely due to the selection of our units. It would also appear that, from the molecular standpoint, the liquid state is really intermediate between the gaseous and the solid states—in other words, that the gas laws cannot generally be extended to liquids.

Water was the first liquid systematically attacked. Water has many peculiarities. It was considered strange that water, almost alone of all substances, should have a maximum density at 4 deg. C. above its freezing-point and that it should expand in freezing. Then Tammann (Göttingen) found, twenty years ago, that there are three or four kinds of ice, not merely differing as to the system of crystallisation, but strongly showing the peculiarities of distinct modifications, stable over different ranges. P. W. Bridgman (Harvard College, Cambridge, Mass.), extending the range of experiments, distinguished five kinds of ice, which he numbered I, II, III, V, VI (he does not accept Tammann's ice IV), possibly with subdivisions, and his equilibrium diagram water-ice is as complex as the iron-carbon diagram. Does water really stand alone? So far it seems so in some respects. But it is as yet too early to speak definitely.

Most solids expand fairly regularly, but not quite regularly, when heated; on melting there is a sudden large expansion (5.5 per cent. in tin), and the heated liquid continues to expand. The cooled liquid contracts and freezes at the same temperature if pressure, &c., be the same. Many substances like quartz and phosphorus pass into different modifications when heated and compressed. All the characteristic points are influenced by pressure. At a pressure of 1 atmosphere* ice melts at 0 deg. and mercury at −38.8 deg.; at 100 atmospheres ice melts at − 1 deg. To melt mercury at 0 deg. the pressure has to be raised to 7,600 atmospheres, which may be called the melting pressure at that temperature. In the case of mercury and most substances the rises of temperature and pressure proceed on parallel lines; at 12,000 atmospheres the melting-point of mercury is + 21.99 deg. C., and the Δt, the rise in the melting-point per 1,000 atmospheres, has throughout the range the almost constant value of about 5 deg. For this reason Bridgman was able to measure some of his pressures by the aid of the electric resistance of a mercury gauge. In the case of sodium the Δt diminishes for the same range, 0 to 12,000 atmospheres, from 16.2 deg. to 5.2 deg.; in the case of carbon dioxide—which melts at −56.6 deg. at 1 atmosphere and at + 93.6 at 12,000 atmospheres—the Δt diminishes from 19.3 to 9.3 deg. (Bridgman).

All liquids and solids, we further find, are compressible, and the absence of some incompressible material naturally renders these investigations very difficult. Graphite, sometimes proposed as reference substance, A. L. Day and Sosman found —at the Geophysical Laboratory of the Carnegie Institution, Washington, where John Johnston, presently to be mentioned, also works—occurs in several modifications. Tool steel seems to be the most suitable material. A pressure of 10,000 atmospheres reduces 1 volume of steel to 0.99, 1 of glass to 0.974. Different kinds of steel and iron had about the same compressibility of 5.3×10^{-7}, aluminium gave 11.7×10^{-7}, Jena glass 2.2×10^{-6}—all at 6,800 atmospheres. Bridgman further reduced the volumes of a dozen liquids, alcohols, ethers, acetone, carbon disulphide, &c., all to about 0.75, by pressures of 12,000 atmospheres. The curves of these liquids all looked regular, the rate of compression decreasing at higher pressures; but they all had their peculiarities, though nothing like those displayed by water; and there is no "normal" liquid. Compressed at 20 deg. C., water contracts to about 0.82 at 9,000 atmospheres; then the volume suddenly drops by 7.5 per cent. of the original volume, after which there is a further steady but very slight compression. We have already stated that the equilibrium-diagram water-ice is very complex; the following melting-points (and corresponding pressures) will exemplify this:— − 8.8 deg. (1,000 atmospheres, ice No. I, see previous column); − 22.0 deg. (2,115 atmospheres, triple point, at which ice I, III and liquid are all possible); −34.7 deg. (2,170 atmospheres, triple point, ice II); − 24.3 deg. (3,510 atmospheres, triple point, ice III, V, II); − 17 deg. (3,530 atmospheres, ice V, liquid); − 4.2 deg. (5,500 atmospheres); + 0.16 deg. (triple point, ice V, VI, liquid); + 12.8 deg. (8,000 atmospheres); + 73.6 deg. (20,000 atmospheres). Thus there are, according to Bridgman, five or six triple points, and ten or eleven transformation lines. Increasing pressure first lowers the melting-point, and then, above 2,115 atmospheres, raises it. All the ices, except I, are denser than water; ice VI is the most stable, and the only one possible above 0 deg. C.; hot water at + 75 deg. would freeze to ice VI at 20,000 atmospheres. The changes are usually rapid at the triple points, but sometimes very slow.

But these features are not altogether singular. In the expectation that the properties of liquids would at low temperatures approximate to the characteristic properties of solids, W. Seitz and G. Lechner, of Aachen, in 1915 submitted some hydrocarbons, alcohols, ethers, &c., to low temperatures and high pressures, partly making use of experimental arrangements similar to those adopted by W. Wahl, of Helsingfors, in the researches which he conducted in the Davy-Faraday Laboratory.* In some cases Seitz found the coefficient of thermal expansion to diminish with falling temperature to a minimum at about −40 deg. C. for alcohols, and at −70 for carbon disulphide, to rise again afterwards. In other cases no minimum was reached at − 120 deg. C. As the pressure was raised to 1,000 atmospheres the tendency of the coefficient of expansion to increase with falling temperature became more marked than at ordinary pressure. Wahl found that solid oxygen is dimorphous, and that methane and some alcohols crystallise

* Pressures are, for the present, understood to be purely hydrostatic, and are expressed in atmospheres, 1 atm. = 1 kg. per sq. cm.

* See Engineering, May 8, 1914, page 638.

in the cubical system; we should refer our readers to his researches. Bismuth, which, like water, expands in freezing, follows the analogy of water in so far as its freezing (or melting) point is lowered (not raised) from 271 deg. C. at 1 atmosphere, as the pressure is raised, to 218 deg. at 12,000 atmospheres; but the curve is quite regular. Heating white phosphorus to 200 deg. C. at 12,000 atmospheres, Bridgman observed a sudden condensation of the vapour, after a gradual fall of pressure, to a grey phosphorus of density 2.7 (against 1.9), which he could not prepare in any other way; this phosphorus resembled graphite and was a fair conductor of electricity. A. Smits obtained grey phosphorus in a different way; there is also a violet phosphorus, whilst the formerly assumed red phosphorus is not now regarded as a pure modification.

Whether or not increased high pressure will continue to raise the melting-point of a solid, or whether the curve will pass through a maximum, which would mean that, at sufficiently high pressure, all solids should liquefy, no matter what the temperature (Tammann), is not settled. Bridgman and Johnston argue that there is no reason for the latter assumption, nor for the analogous suggestion that there must be a critical end-point in the liquid-vapour curve. When saturated steam is superheated in the presence of water the liquid and vapour phases become indistinguishable at the critical end-point of about 370 deg. at 200 atmospheres (365 deg. C. and 194.6 atmospheres according to Battelli). Below the critical point, but not above it, increased pressure will always condense part of the steam. But the water vapour or gas might directly condense to ice, as the phosphorus does. In the case of carbon dioxide the critical temperature is + 31 deg. when the pressure is 5,500 atmospheres. Beyond that temperature only gas and solid CO_2 seem possible, and the melting curve is quite regular and does not show any break or inflection at the critical temperature. These considerations are of high geophysical importance. From the absence of tidal motion within the interior of the earth and the rate of propagation of earthquake waves—which may describe an arc in the solid crust, or travel in a chord right through the interior—it seems to follow that the interior of the earth must be solid and cannot be liquid. But the subject is too obscure, and would be so even if the problems were merely physical, and if chemical reaction did not come into play. Minerals, so far as investigated, expand with fair regularity; in the case of rocks the phenomena are complex.

So far we have referred to uniform, purely hydrostatic pressure. Non-uniform pressure, of the nature of a shear, should affect solids only and not affect the cases mentioned, in which the specimens were placed within compression chambers filled with kerosene or gasolene—the viscosity of which increased enormously. But non-uniform pressure would enter into the phenomena of the liquids when there is a possibility of the presence of both a solid phase and a liquid phase; there might also be some unintended contact between solids in the experiments, or at any rate restriction in the free propagation of changes in the hydrostatic pressure. One can understand that uniform and non-uniform pressures may have different effects, and that the effects of a shear superposed upon a uniform pressure will be relatively very strong, especially when acting upon a small area. But it is difficult to see why—quite in general, as Johnston put it—uniform pressure should raise the melting-points and non-uniform pressure should lower them. Shear above the elastic limit results in a deformation from which the solid cannot recover. It requires some effort to imagine that uniform stress, sufficiently strong to produce an appreciable compression, can be altogether devoid of a shear, though the elastic theory makes that demand.

The effect on a melting-point or a transition point (at which one solid modification passes into another) of unknown extra stress, not hydrostatic, has received very meagre attention, as Bridgman pointed out last year. In his own consideration, which he bases on Voigt's general thermodynamic potential of solids under stress, he suggests that two phases of a substance, initially in equilibrium with one another, are in contact across a membrane permeable to the reacting phases. That fictitious membrane, he admits, is a severe strain on the imagination, and his conclusion is not easy to understand either: "A solid subjected to any stress system whatever (tension, compression or shear) experiences a *depression* of the melting-point at the *unstressed* surface (or at a surface stressed by less than the average amount), and melting will take place at that surface if the stress be high enough." The statement is free from all hypothesis as to the nature of the contact between the crystalline grains. Plastic flow, he maintains, is produced under certain conditions by an actual melting with regelation of those crystalline grains which bear the brunt of the stress, this local melting being governed by the equations for an unequally-stressed solid, and not by the equations for a solid under hydrostatic pressure in equilibrium with a liquid not under pressure. This contributory agent in plasticity does not appear to Bridgman to be largely effective in the majority of practical cases, however, for many substances an analogous effect due to the displacement of polymorphic transition points would be of more importance.

Some thirty substances were examined by Bridgman as to polymorphic changes, alkali salts, organic compounds, &c., and two or three modifications were found in most of these cases, whilst a hundred other substances did not show transition points. One might expect that the phase with the smaller volume would display the smaller compressibility and the smaller thermal expansion, and that the phase which is stable at higher temperature would have the higher specific heat. From this point of view, however, there were, in the several respects, as many normal substances perhaps as abnormal substances. The case of mercuric iodide (known in a yellow and a red modification) is interesting; the transition curve had a maximum at 4,800 atmospheres and 181 deg. C.

As regards electrical resistance Bridgman found that pressures up to 12,000 atmospheres reduced the resistance of 22 metals, in all cases, except those of bismuth and antimony; this exceptional behaviour of antimony was unexpected. The changes in resistance amounted to as much as 12 per cent. in some cases, and the pressures applied would, with respect to compressibility, probably reduce the volumes of the metals in question to less than the volumes at absolute zero temperature. The temperature coefficients changed very little with pressure.

One can scarcely picture to oneself what should, from a common-sense point of view, take place at high compression. Too many factors enter, of similar and of opposing natures; the thermal factors—latent heats, specific heats, conduction, &c.—are complex in themselves. Pressure effects on chemical reactions—disregarding cases in which gases play a part—on solubility, electrolytic conductivity, &c., seem to be weak; as long as pressures of a few atmospheres only were tried, the effects were possibly underrated; later on they were overrated.

The question of purity becomes of the utmost importance at high pressures. A good deal of what is regarded as plasticity may be due to traces of impurity which will influence chemical reactions, the specific heat and local melting. For various reasons the surface layer of a substance is frequently considered as being distinct from the material underneath, and we do not know in how far the liquid medium in which a solid is being compressed might count as impurity. The high pressures of modern laboratories may be insignificant, moreover, compared to the pressures in the earth's crust, which raised continents and mountain ranges and folded and broke and actually turned topsy-turvy strata many hundreds of feet in thickness. They may be insignificant also compared with molecular forces. Yet they might release molecular forces which only come into play at close contact. Then the influence of the shape of the molecule and atom would exert itself, and if the atom be not an entirely homogeneous sphere, but something possessing a structure in which local centres of force will exist, the extreme complexity of compression and concomitant phenomena would appear less incomprehensible.

PEAT POWDER FUEL FOR THE SWEDISH STATE RAILWAYS.

The problem of exploiting the world's vast peat deposits in a rational and remunerative manner has tempted many an engineer and many an inventor, but on the whole the results so far have hardly been satisfactory, with a few isolated exceptions. The country which seems to have brought the problem nearest the desired solution is Sweden, where several eminent engineers, amongst them the late Dr. Gustaf de Laval, have taken up the question with much interest and perseverance. The Swedish State, always willing to aid enterprises designed to exploit the country's natural resources, has herself, through the medium of the State railways and with their working in view, undertaken important work which may now be said to have passed successfully beyond the initial stage.

Some seven or eight years ago the Swedish State railways commenced tests of air-dried peat for locomotive fuel, but the experiments, for various reasons, did not altogether encourage further experiments, and the matter was dropped for the time being. In the year 1914, however, the peat problem again asserted itself, although under another form, and the State railways at once prepared to take up the matter when they learned that peat powder had been successfully tried as locomotive fuel on the private Rimbo railway. The requisite appliances were fitted to a locomotive with a view to testing the principle on the State railways, and peat powder was purchased. (See "Peat Powder as Locomotive Fuel," Engineering, October 20, 1916.) A locomotive fitted for burning peat powder has been used ever since the spring of 1914, and it may now be maintained that peat powder can be used commercially for locomotive fuel, which is more than can be said of air-dried peat. It has been proved that peat powder will enable a locomotive to meet ordinary traffic conditions in Sweden and to run in a perfectly satisfactory manner.

Amongst the various advantages of peat powder, as compared with ordinary peat fuel, may, be mentioned the fact that its proportion of water can easily be kept below 12 per cent. to 15 per cent., and that it lends itself admirably to automatic stoking. The tests referred to above were so encouraging that it was decided to continue the experiments with peat powder fuel on a much larger scale. Large and regular supplies of peat powder, beyond what could be reckoned upon from private concerns, being necessary for this purpose, the State railways first of all had to construct a peat-powder factory. It was decided to erect it at the Hästhagen peat deposits, near Vislanda, and to adopt the Ekelund system. The Swedish Riksdag, in 1916, voted a grant of 70,000*l.* for this purpose. An arrangement was made with the existing peat-powder factory to carry out the work, the State railways, however, finding the necessary Decauville material, engines, boilers, &c.

The peat deposits in question cover an area of some 500 acres, with an average depth of rather more than 6 ft. 6 in., representing about 5,000,000 cub. m. of peat; the annual production is calculated at 20,000 tons of peat powder, which represents 220,000 cub. m. of natural peat. This peat is raised by means of three electrically-driven digging machines; the output from each machine has been put at about 30 cub. m. per hour, 700 cub. m. for the 24 hours, and 70,000 cub. m. during the 100 working days per annum which are reckoned upon. Each machine, however, has a guaranteed capacity of 45 cub. m. per hour. The machines are to leave a layer of peat with a view to future cultivation. As the work proceeds the denuded portion of the area is levelled and sown with grass so as to produce a firm surface.

From the digging machines the peat passes into Decauville trucks, which run on lines placed alongside the area operated on by the digger. As soon as one truck is filled another is placed under the delivery shoot of the machine, and when 8 or 10 trucks have been filled they are drawn by a motor locomotive and discharged on the drying field, the rails being shifted sideways as the place becomes filled with mounds of peat tipped from the trucks. The peat thus deposited is spread out

by means of a specially constructed apparatus, consisting principally of a frame resting on four wheels and of four screens placed between the side plates. Of these screens the two foremost have a shape something like a snow-plough, the two latter being straight. None of these four screens quite reaches the ground. The first is placed at a somewhat greater distance from the ground than the second, the second again than the third, &c. The distance between the fourth screen and the ground is regulated according to the desired thickness of the peat. This peat spreader is drawn, by means of ropes and electric winches, to and fro, over the rows of peat mounds. The first plough-shaped screen cuts off the top of the peat mounds and begins the operation of spreading, this operation being continued by the second and the third screens. Any surplus of peat is collected in the space between the third and the fourth screen, and in its turn deposited where the peat layer is too thin.

By this process a fairly evenly distributed and uniformly thick layer of peat is spread over the drying field, and by means of cutters at the back of the frame of the spreader the peat is cut in strips, which again, by another appliance, are cut crossways, whereby the peat is divided into small rectangular pieces. The peat is now left exposed to sun and wind, and when the upper surface is fairly dry the peat squares are turned, in order that the other side may get dry. This done, the peat squares are gathered in small stacks for further drying. When the percentage of water has been reduced to some 40 per cent. the peat is ready for the pulverising process and is now conveyed by Decauville trucks into peat sheds, from whence it in turn proceeds to the factory. All the peat likely to be wanted is promptly conveyed to the factory, where four sheds, each with a capacity of 2,000 tons, will be erected, the rest of the peat being stacked.

The "powdering" process comprises three stages, viz., crushing, drying and pulverising, or grinding. The peat is first carried to a crushing compartment, where it passes through a coarse and a fine crusher. By means of a screw conveyor the crushed peat is brought into the drying ovens, which are heated with residue from the pulverising process and ordinary air-dried peat. The gases are forced through a series of bricked passages, above and parallel with each other in the drying oven. Above each of these passages and separated from them by bottom plates of cast iron, runs a similar passage for the peat. This enters the topmost peat passage, is forced through this by means of a transporter, falls at the ends of this passage into the next, and so on. The peat passages are heated by the combustion passages underneath them, just referred to, the peat on entering the oven being exposed to the heat from the hottest gases.

The dried peat is now transferred to the crushing room by means of a screw conveyor, but before entering the grinding mill it passes through a sieve, so that the powder already formed during the drying process is separated ready for use. From the grinding compartment the peat powder, by means of conveyors, is taken from the factory to a bunker, from which it runs down into specially-constructed tank trucks, by which it is carried to bunkers constructed at convenient places alongside the line.

A tender designed to carry peat has, above the water tank, a fairly high receptacle fitted with two airtight doors for the filling in of the powder. The bottom of the peat receptacle is in the shape of a stumpy reversed pyramid, so that the powder can more easily slide down to the bottom. Through and from this proceeds a cast-iron pipe, through which passes a smaller iron pipe, ending in a cone, which can be moved up and down. Another pipe conveys the peat powder to the fire-box of the locomotive. On the locomotive there is an air compressor, worked by a rotary steam engine of the Hult system. The compressed air is passed through the pipe in the bottom of the receptacle, the result being a small excess pressure in the airtight peat powder receptacle. As the feeding of the peat powder is effected by means of a rod in the driver's cabin, the adjusted pipe is lowered a little, whereby the peat powder is forced by the excess pressure into the transport pipe and conveyed to the fire-box. The powder falls into the fire-box at a fairly slow speed and meets there the current of the combustion gases from a small coal fire placed below the inlet pipe. The consumption of coal for this fire amounts to 3 kg. to 4 kg. per 100 kg. of peat powder. So as to be able automatically to stir and move the powder four branches proceed into the corners of the receptacle from the pipe fixed below its bottom, and in these branch pipes there is a number of small holes, through which the air is blown into and stirs the peat powder.

The tests which have been undertaken with this locomotive have shown that about 1.5 kg. of peat powder generate the same quantity of steam as 1 kg. of coal, provided that the respective heating values of the two kinds of fuel are 7,700 units and 12,600 units. In other words, the heating value of peat powder is about two-thirds that of coal.

We are indebted to the bureau engineer, Mr. G. E. Rendahl, for these particulars. He distinctly points out that this work on the part of the Swedish State railways is but one phase in the effort of exploiting Sweden's home fuel, more especially the peat deposits, and he expresses the hope that the desired end may soon be fully attained.

NOTES.

The Schoop Metal-Spraying Process.

We have on various occasions referred to the process by which Mr. V. Schoop, of Zurich, fuses a wire of metal and converts the fused drops, by means of the blowpipe blast, into a fine spray which settles to a coherent coating on any surface it strikes and cools sufficiently not to burn paper or celluloid when they are to be metallised in this way. We described the pistol used for this purpose on page 110 of our issue of July 30, 1915. Even iron and copper have been sprayed by this process, and it has been claimed that objects can be coated with alloys like brass by simultaneously metallising with copper and with zinc, without any further heat treatment. This latter claim does not seem compatible with the rapid cooling of the particles relied upon in the case of combustible objects, though some mechanical union of the hot small particles seems to be necessary to account for the adhesion of the coating. Examining the coatings microscopically, H. Arnold (*Zeitschrift für Anorganische Chemie*, 99, pages 67 to 72, 1917) questions the formation of alloys. He points out that the drop of fusing metal is, by the gas and air current, drawn out into a thread which breaks up. Years ago, before the Schoop process was spoken of, Messrs. Strange and Graham squirted fused lead, zinc and tin and other metals in long threads or ribbons, it will be remembered,* which found application in the white lead industry and as substitutes for the zinc shavings of cyanide baths, for instance. Working in the laboratory of the Metallisator Company, of Berlin, Arnold finds that in the case of aluminium the projected metal thread is broken up into small particles which, on striking a cold surface, flatten out into splashes from 0.01 mm. to 0.15 mm. in diameter, each provided with a short tail; the splash shows a kind of dendritic texture of the metal. When an aluminium coating on iron was etched with alcoholic soda, wavy lines could be seen which were not due to the superposition of several layers of the metal; when the coating was polished so as to display the structure in a plane at right angles to the projection ring lines were noticed, marking the outlines of the splashes. When zinc was sprayed on glass, to which it does not adhere well, irregular crescent-shaped splashes were formed, because the metal peeled off again in spots and contracted; in the case of tin double rings, formed by the union of two adjacent rings, were observed, and fine lines were noticed in the metal, somewhat as in agate. There was no alloying apparently, except perhaps with lead and antimony, but not in thin layers of these sprays. Zinc and copper did not diffuse into one another and did not alloy, unless subsequently heated. The union seemed to be merely mechanical. Under the microscope the sprayed-metal castings could easily be distinguished from electrolytic and other coatings, even when aluminium had been sprayed on iron and then rolled in. The photographs illustrating the paper also show the appearance of sprayed iron and copper.

* See Engineering, February 5, 1909, page 192.

Triboluminescence.

Although the phenomena of triboluminescence have been known for a century, their explanation has made very little progress. When a piece of sugar is crushed in the dark a certain luminosity is observed. Quartz crystals and crystals of uranium nitrate show this triboluminescence still more strongly. The first account of observations of this peculiarity is generally ascribed to Dessaignes. Looking up the literature on the subject, Dr. A. Imhof, of Zürich University, finds, however, a still older treatise, of 1820, on the "Phosphorescence of Bodies," by P. Heinrich. Quite a number of new researches have been published in this century; J. Burke first observed that the triboluminescent spectrum is continuous. As different investigators are by no means in agreement, however, Imhof confines himself in his recent paper (*Physikalische Zeitschrift*, February 15, 1917, pages 78 to 91) to a tabulation of his own observations, without discussing at length the various suggestions made that triboluminescent substances should preferably be electric insulators, symmetrical and optically active compounds, that isomers should behave similarly in this respect, &c. He examines a large number of inorganic and organic substances, salts and minerals, crystallised and amorphous, glass, &c., studying in particular so far the minimum size of crystal, the colour of the luminosity and the influence of temperature. In his experiments he rubs the substance in a small glass bottle (with wide neck) with the aid of a blunt-pointed rod of ivory or glass. He finds that the minimum size of particle which will reveal triboluminescence is 0.001 mm. for zinc sulphide (calcined, not free from manganese), 0.02 mm. for willemite, 0.06 mm. for quartz and uranium nitrate, 0.14 mm. for sugar, 0.7 mm. for white fluorspar, &c. Very fine powders no longer show triboluminescence. Sometimes the triboluminescence increases when the substance is heated (quartz still shows it at faint glow); as a rule it becomes more distinct when the substance is cooled (down to — 80 deg. C.). At low temperatures the colour changes towards the violet, if originally yellowish or greenish-blue. Imhof found that when heat destroyed the triboluminescence, cooling or radio-active radiations restored it. Elementary substances did not display the phenomenon; sulphur was doubtful, diamond was not tried, we notice. Most double alkali sulphates were triboluminescent, the chrome-alums excepted. Sodium carbonate crystallising with 10 molecules of water was so, the same salt with one molecule of water, or amorphous without water, was not. Chemically related substances generally behave similarly in this respect; but there are exceptions. The light was mostly bluish, sometimes yellow or orange, very rarely white or red. Phosphorescent substances retained their quality when the phosphorescence vanished on heating. One fact is rather striking in Imhof's account. There is no allusion to the popular belief that the luminescence produced by crushing is due to electrification by friction. If that be so, hardness, brittleness and dryness of the substance might be of more influence than chemical composition, and one understands why the hydrated salt should differ from the anhydrous salt. Perhaps Imhof will deal with this feature in a second paper.

Emulsification Test of Lubricating Oils.

Lubricating oils are not supposed to wear out mechanically by long-continued use; but there is very little experimental evidence as to this. Chemically, lubricants may be affected by overheating and by the action of impurities like traces of acids; but again we have hardly sufficient experimental data. The most common trouble of lubricants is their tendency to emulsify with the water which gains access in some way. Whether or not the emulsification directly impairs the lubricating power of an oil is again more a matter of conjecture than of actual experiment. There is no doubt, however, as to the indirect disadvantages of having to deal with oil emulsions instead of with

oils. To be re-used the oil has to be filtered, and the oil emulsion may clog the filter and cause a temporary failure of the oil feed, leading to serious consequences. On the other hand the oil gets into the condensed steam and creates a difficulty in the boilers, &c. Hence oils which will not readily emulsify are preferred for certain machinery, and various emulsification tests have been proposed. They are all arbitrary, and an absolute test has not so far been devised. In Technologic Paper No. 86 of the United States Bureau of Standards Mr. Winslow H. Herschel describes a type apparatus which admits of assessing numerical values. What he determines is the demulsibility, *i.e.*, the rate at which an emulsion of water and oil will separate into its constituents again, the assumption—again probably justified, but not proved—being that an oil which will readily demulsify will readily have emulsified. When observations are made on a settling mixture of oil and water it is noticed that there appears a meniscus between the emulsion and the layer of oil forming above it; this meniscus travels downward, and it is the one observed in the new test. There is another, less distinct, meniscus between the water and the emulsion advancing upward. After experimenting in various ways Herschel performs his test in a cylindrical glass cup, 26 mm. in diameter, of 100 cub. cm. capacity, into which he charges 20 cub. cm. of the oil and 40 cub. cm. of distilled water (tap water is usually as good); into the mixture dips a flat copper paddle, 89 mm. long, 20 mm. wide, 1.5 mm. thick, which is turned by an electric motor above the cup at the rate of 1,500 r.p.m.; the cup is kept at 55 deg. C. (130 deg. F.) in a water bath. After agitation for 5 minutes the mixture is allowed to settle, readings being taken at intervals of 1 minute for an hour at most. When the mixture has all separated in 1 minute the demulsibility figure is 1,200 (20 cub. cm. and 60 minutes), this being the possible maximum. If 10 cub. cm. of oil separate out in 15 minutes, the rate would be $(60 - 50) \times 60/15 = 40$ cub. cm. per hour. The paddle has to be wiped with the finger, not to lose oil in the test, and there may be difficulties with very dark oils, and with drops of oil adhering to the cylinder wall. The rates observed depend, moreover, on the speed, time, proportion of mixture, temperature, &c., and the designers of similar apparatus, and practical men may raise various objections before the test can be adopted as a standard test. The Bureau communicated with engineers, and it resulted that new oils generally gave high demulsibilities (from 192 upward in the case of steam-turbine oil, *e.g.*), and old oils lower values (98 maximum, after 10 months' use). But the point seems to be that oils of lower demulsibility, 41 and less, were frequently considered satisfactory after a year's use, and as it is common practice to replenish the oil with oil of the same brand—which does not necessarily mean the same oil—one does not quite see what these tests really signify and achieve, though the emulsion tests may be more expeditious and even more reliable than the difficult chemical tests. Certain adulterations of the oils betray themselves in the demulsibility.

National Association of Industrial Chemists.—The Provisional Executive appointed by representative chemists employed in Sheffield and district has been for some weeks considering the basis, rules and constitution for the proposed National Association of Industrial Chemists. Its conclusions will shortly be published in book form, and every industrial chemist and metallurgist of Great Britain and Ireland may at once apply for a membership form. About 100 chemists have already been declared full members. All communications should be addressed to The Propaganda Committee, Bailey-street Schoolrooms, Sheffield.

A Standard Aeroplane Engine.—An interesting paragraph is contained in *The Iron Age* of July 5, to the effect that the National Advisory Committee for Aeronautics, United States, has made the following announcement: "The Aircraft Production Board, realising the need for the development of a standard engine in various sizes, has succeeded in obtaining the co-operation of two of the foremost engine designers in the country, Messrs. Vincent and Hall. The fundamental idea of the engine is a unit cylinder, by means of combinations of which any desired power may be obtained. It is proposed at first to build engines in four sizes, of 4, 6, 8 and 12 cylinders, the corresponding horse-powers being approximately 100, 200, 300 and 400."

THE RAILWAY PROBLEM.

No. I.—BRITISH RAILWAYS BEFORE THE WAR.

Of the many important questions which will have to be settled after the war, one of primary importance is that of the future relations of the railways to the State, the public, and the traders of the country. We believe that the Reconstruction Committee has already given some attention to the matter, and we may recall that in October last in the House of Commons a member was informed that "the question of the relations between the State and the railways after the war is not being overlooked."

Engineering firms are greatly concerned in the railway problem, and therefore we propose to devote some attention to it. To enable the future to be gauged with any degree of probability it is necessary to examine the position of affairs before the war, and to ascertain the most important developments since that memorable August 4, 1914, when it was announced that an Order in Council had been made under the Regulation of the Forces Act, 1871, declaring that it was expedient that the Government should have control over the railways in Great Britain.

The year 1913 was a prosperous one for British railways. On the one hand traffic receipts were high, and on the other, although expenditure had swollen considerably in consequence of concessions to the staff, there was a growing tendency to abolish wasteful competition and to adopt improved methods of operation, thereby effecting economies. The result was that the net receipts for the year 1913 were greater than they had ever been in the history of railways. Before giving the figures we may recall that the year 1913 was also exceptional as marking the commencement of a new method of compiling railway companies' accounts. On January 1, 1913, a new Act—The Railway Companies' (Accounts and Returns) Act, 1911—came into force, whereby each railway company in the United Kingdom was required to furnish to the Board of Trade annual accounts and statistical returns in accordance with forms set out in the first schedule to the Act. This change included a very considerable expansion of the accounts of revenue receipts and expenditure, separate figures being given in respect of the railway proper and for each subsidiary undertaking, such as steamboats; canals; docks, harbours and wharves; hotels, refreshment rooms and dining cars; and other separate businesses. The effect of the change was that the published figures for the year 1913 were not properly comparable with those for previous years. But the principal items may be contrasted, and we give the following figures for the decade 1904–1913:—

Year.	Gross Receipts from all Sources.	Working Expenditure.	Percentage of Gross Receipts.	Net Receipts.
	£	£	Per cent.	£
1904 ..	111,833,272	69,172,531	62	42,660,741
1905 ..	113,531,019	70,064,663	62	43,466,356
1906 ..	117,227,931	72,781,854	62	44,446,077
1907 ..	121,548,923	76,809,194	63	44,939,729
1908 ..	119,894,327	76,407,801	64	43,486,526
1909 ..	120,174,052	75,037,588	62	45,136,464
1910 ..	123,925,565	76,369,676	62	47,355,889
1911 ..	127,199,570	78,617,824	62	48,581,746
1912 ..	128,553,417	81,224,343	63	47,329,074
1913 ..	139,451,000	87,320,000	62.62	52,131,000

After making due allowance for the change in accountancy, it is clear that the growth of net receipts in the year 1913 was extraordinary. Moreover, the new form of accounts brought out the fact that the railways were making substantial appropriations to reserve and other special purposes, and generally that their financial position was sound, especially in the case of the larger companies. To this point we shall again refer in considering the question of railways after the war: for the moment we merely desire to say that while much maintenance and renewal work has had to be deferred in consequence of the war, the necessary appropriations and provisions from revenue are being set aside for expenditure when circumstances are propitious.

But the year 1913 was noteworthy for other important reasons, and there were many problems confronting the railways. The most important was that of labour, while next to it was the growth of criticism by traders and others, largely due to the fact that railway companies were "getting together" in more ways than one to minimise competition, increase receipts, and decrease wasteful expenditure. As regards labour questions, the growing power of trade unionism and consequent demands for improved conditions of service date from the year 1907. Following upon a period of extreme agitation in support of the "All-grades programme," the present Prime Minister, as President of the Board of Trade, had succeeded in bringing about a settlement by the establishment of Conciliation Boards. Matters remained fairly quiet during the next three years, but agitation and discontent broke out afresh in 1911, and in August of that year there was a general strike of railwaymen. We are not here concerned with the cause of that strike, but the terms of settlement provided for two things: the Government undertook to appoint a Royal Commission to investigate the working of the conciliation scheme, and promised to "propose to Parliament next session legislation providing that an increase in the cost of labour due to an improvement of conditions for the staff would be a valid justification for a reasonable general increase of charges within the legal maxima if challenged under the Act of 1894."

The Royal Commission revised the conciliation scheme, and after some negotiations it was accepted by all parties. Very extensive betterments of service conditions were granted to the men in the autumn of 1911 and during 1912. But the year 1914 was apparently to be the commencement of another period of unrest. The conciliation scheme was to remain in operation until November 6, 1914, and thereafter be subject to determination as regards any company by twelve months' notice given by the company or by a majority of the aggregate representatives of employees on all the Conciliation Boards for each company's system. It followed, therefore, that the earliest date on which notice to determine the scheme could be given was November, 1913, and very shortly after that date the railway companies were notified of the men's desire to terminate it. At the same time it was intimated that the unions wished to negotiate a revised scheme, and meetings with that object in view were held in June and July, 1914, between representatives of the railway companies and of the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen. These negotiations were interrupted by the war. What the men had in view is apparent from the terms of the programme which it was intended to bring before the new conciliation boards on the termination of the various settlements early in the year 1915. The chief features were: (1) An eight-hours' day or a 48-hours' week for all railwaymen; (2) a guaranteed working day and week, independent of Sunday duty; (3) an immediate increase of 5*s.* a week on the minimum and maximum rates and on the bonus and piece rates for every grade in the service; (4) absolute and complete recognition of the union in any future conciliation scheme. Had these demands been conceded by the railways the addition to their wages bill would have been not less than 16,000,000*l.* per annum. The war caused the "programme" to be held in abeyance, and it—or a new one—presumably represents an after-the-war problem. What has now to be remembered is that at the time war broke out the railways were faced with the most extreme demands that had ever been made by or on behalf of their employees, and that the machinery for negotiating conditions of service, viz., the conciliation scheme, was in process of negotiation, although there was at the time every reason to believe that the basis of a new scheme had been agreed. As we shall show later, this is substantially the position as it now exists.

As regards railways and the State, and railways, the public and the traders, there were before the war a variety of questions outstanding. In the year 1908 Mr. Lloyd George, as President of the Board of Trade, arranged what was known as a Railway Conference. It was constituted without any rigid terms of reference, with the object of

reviewing some of the more important questions that had from time to time been raised between the railway companies on the one hand and the traders and general public on the other. The subjects discussed included questions connected with the acquisition and holding of land by railway companies, increase of railway rates, owner's risk conditions, the machinery for the settlement of disputes between railway companies and traders, and the desirability of forming an Advisory Committee on railway matters. Sub-committees of the Conference discussed matters arising in connection with railway working agreements and amalgamations, and special points affecting railway charges and facilities, including the Carriers Act, dangerous goods, private sidings, private owners' wagons, detention of trucks, &c. Certain of the recommendations were given effect to, but in the main they required the authority of Parliament. Meanwhile, however, another committee had been appointed. This time it was a Departmental Committee arranged by Mr. Winston Churchill, who had succeeded Mr. Lloyd George as President of the Board of Trade. The terms of reference were: "To consider and report as soon as practicable what changes, if any, are expedient in the law relating to agreements among railway companies, and what, if any, general provisions ought to be embodied for the purpose of safeguarding the various interests affected in future Acts of Parliament authorising railway amalgamations or working unions." The appointment of this committee was due to the magnitude of proposals that had been made openly or arranged by agreement for amalgamation of railway interests. The most far-reaching of these was the scheme of fusion of the Great Central, Great Eastern and Great Northern Railways—a project which, failing approval by Parliament, has been largely effected by mutual agreement. Other arrangements of the kind are the pooling agreements between the Lancashire and Yorkshire, London and North-Western and Midland Companies, and between the Great Western and London and South-Western Companies. The policy of Parliament practically throughout last century was to encourage competition, but without avail. To quote an admirable summary of the situation from the report of the Select Committee of 1872: "Committees and Commissions carefully chosen have for the last thirty years clung to one form of competition after another; it has nevertheless become more and more evident that competition must fail to do for railways what it does for ordinary trade, and no means have yet been devised by which competition can be permanently maintained. In spite of the recommendations of these authorities, combination and amalgamation have proceeded at the instance of the companies without check, and almost without regulation. United systems now exist, constituting, by their magnitude and by their exclusive possession of whole districts, monopolies to which the earlier authorities would have been most strongly opposed. Nor is there any reason to suppose that the progress of combination has ceased, or that it will cease until Great Britain is divided between a small number of great companies." This statement was as true in the 'nineties as in the 'seventies—but within the last decade there has arisen a determination to secure that, side by side with combination of railways, the interests of traders shall be safeguarded.

The Departmental Committee on Railway Agreements and Amalgamations reported in 1911. But before its recommendations could be given effect to there occurred the strike of railway employees to which we have already referred, and the consequent pledge of the Government to authorise the acceptance of an increase in the cost of labour due to improvement of conditions of the staff as a valid justification for a reasonable general increase of charges. The Government proceeded to give effect to this pledge, but in the same Bill—the Railways Bill of 1912—they proposed also to give effect to certain of the recommendations of the Board of Trade Railway Conference, and of the Committee on Railway Agreements and Amalgamations. For example, any diminution or withdrawal of a facility or service, and any charge for a facility or a service hitherto rendered without charge, was to be deemed to be an increase of rate, to be justified if challenged under the Railway and Canal Traffic Act of 1894. On the other hand, if a rate were reduced experimentally, and the railway regarded it as not justified by results, and consequently partly or wholly restored the former figure, the burden of proof was to be removed from the railway company to the complainant. Other clauses were to empower the Board of Trade to alter the statutory classification of merchandise traffic for maximum rates where the circumstances affecting the articles had radically altered since the classification was made; for imposing on railway companies liability for loss or damage not due to insufficient packing where goods are carried only at owner's risk if insufficiently packed; and for requiring a separate statement of cartage rebates in rate books. Then there was an important provision, based on the report of the Committee on Railway Agreements and Amalgamations, to enable railway companies to enter into agreements for the maintenance and working of their lines and the apportionment of receipts; but railways worked by one company were to be counted as one for the purpose of calculating maximum charges, the effect being to reduce the maximum rates on traffic passing over more than one of the lines. All working and other agreements were to be made public.

This Bill met with strong opposition, the railway companies contending that it more than took away with one hand what it gave with the other. Ultimately it was withdrawn, and in the following session of Parliament (1913) a one-clause Bill (Railways No. 2) was introduced and passed. It was admittedly an unpopular measure, but was eventually accepted on the ground that the Government pledge of August, 1911, was one that could not honourably be left unfulfilled. The resultant Act—Railway and Canal Traffic Act, 1913—provided that any increase of rate within maxima must be upheld by the Railway and Canal Commissioners on proof by the railway that there had been a rise in the cost of working resulting from improvements made since August 19, 1911, in the conditions of employment of their staff; that the whole of the particular increase is part of an increase of rates for the purpose of meeting such increased cost; that the increase is not greater than is reasonably required for the purpose, and that the proportion of the increase allocated to the particular traffic as to which complaint is made is not unreasonable. The railways had already increased their goods rates by 4 per cent., and had made other changes, including an increase in the charges for season tickets, and many complaints were made to the Railway and Canal Commissioners. At least one of these, viz., the Associated Portland Cement Manufacturers *versus* the Great Northern Railway, has since been heard, and the increase of rates sanctioned.

The general result of the failure of the Railways Bill of 1912, the passing of the single-clause Bill of 1913, the increase of rates, the tightening up of their arrangements by railway companies, and the progress of working agreements and understandings, was to focus upon the companies a large amount of criticism, and in November, 1913, a Royal Commission on Railways was appointed. Lord Loreburn, G.C.M.G., was chairman, and the terms of reference were: "To inquire into the relationship between the railway companies of Great Britain and the State in respect of matters other than safety of working and conditions of employment, and to report what changes, if any, are desirable in that relationship." The then President of the Board of Trade, speaking at Leicester on October 23, 1913, said: "My experience at the Board of Trade has continually and continuously confirmed the view that all is not well between the railways and the traders and the community. My experience in connection with the two Railway Bills was significant of the friction which exists, and which tends to increase rather than to abate. At the same time the great extension of amalgamations and working agreements has altered the whole position as regards competition and monopoly, and the position of the railways in reference to the State. . . . The terms of reference are drawn very wide, so that the Royal Commission will be able to deal with every aspect of the problem of the relations between the railways and the community." The proceedings of the Royal Commission were interrupted by the war and, presumably, will not be resumed while hostilities are in progress.

To sum up the pre-war railway position of affairs, we may safely claim that while the railways were enjoying a period of unexampled prosperity, judged from the standpoint of traffic and revenue in the year 1913, they were faced with very extensive demands from their employees, while freighters were by no means in a contented or complacent frame of mind. The conciliation scheme for settling employees' wages, hours and conditions of service was "in the melting-pot," there were a variety of recommendations by the Board of Trade Conference and various committees awaiting legislative acceptance; while the whole question of railways in their relation to the State, the public and the traders was under consideration by a Royal Commission.

TUNGSTEN ORES.

The word *tungsten* is Swedish and signifies "heavy stone." The ores are somewhat widely distributed in nature, and concentration into commercial deposits has occurred in many places; but they are irregular, they lack continuity, and are in many localities soon exhausted. Unfortunately, so far no really large deposit has been found which would ensure a continuously steady supply to the market. There are only a limited number of tungsten ores mined—wolframite and ferberite, scheelite and hubnerite; all heavy, ranging from 6 to 7 in specific gravity, with a hardness of 4.5 to 5.5; none of them has a distinctly metallic lustre. Not many years ago these ores were thrown away, now they are sought for on account of their tungsten.

Wolframite is composed of tungsten, iron, manganese and oxygen, or tungstate of iron and manganese. The mineral is frequently associated with tin ores and with quartz, pyrite, scheelite, sphelerite and others. It occurs in various forms—massive, tabular, as prismatic crystals and granular. In colour it is black or greyish-black; its lustre is sub-metallic; the streak is deep brown to almost black; the cleavage is perfect and the fracture uneven. Its hardness is 5 to 5.5; specific gravity, 7.2 to 7.5. Wolframite fuses readily to a magnetic globule and somewhat resembles magnetite, being slightly magnetic before being fused. Magnetite is somewhat lighter and gives a black streak; it is extremely magnetic before being heated, and has a distinct metallic lustre.

Wolframite may be considered more in the nature of a basic phase of the refractory siliceous ores than as a separate and distinct deposit, for it always occurs in connection with them. Occasionally it may form a ring round the outer edge of the siliceous ore shoots, frequently extending inward and upward, so as to form a thin capping to them. It thus appears as a sort of envelope to the siliceous ore mass, which it practically encloses on all except the lower side. Margins of this description are frequently from 2 ft. to 2½ ft. thick, but the capping portion is generally thinner. In many localities wolframite occurs in irregular masses scattered through the siliceous ore, or in stringers, or thin contorted layers in the silicified rock. It may occasionally be kidney-shaped, or may form lenticular masses in the country rock.

Scheelite is composed of calcium, tungsten and oxygen, or calcium tungstate. It is found associated with free-milling quartz in granites and slates, also with fluorite, apatite, &c. It is generally found massive, columnar, or reniform or kidney-shaped. Its colour varies; it occurs white, yellowish-white, pale yellow, brown and reddish. The lustre is vitreous, the streak white, with a good cleavage and an uneven fracture. The hardness ranges from 4.5 to 5; the specific gravity is 5.9 to 6.1; it is brittle and practically infusible by ordinary methods. Hydrochloric acid decomposes scheelite, leaving a yellow powder. In appearance it somewhat resembles orthoclase, but it may be readily distinguished from it by its solubility and specific gravity; It also resembles a few carbonates and sulphates, but it may be distinguished from the carbonates by not effervescing in acids, from the sulphates by not turning a silver coin black after it has been heated, moistened and placed on one.

Hubnerite is composed of tungsten, manganese and oxygen, it is also known as tungstate of manganese. It occurs with scheelite in veins, with quartz, fluorite, apatite, &c. The colour is brown, or brownish-red to brownish-black; lustre resinous to semi-metallic; the streak is brownish-yellow. It has a good cleavage, its hardness is 5 to 5.5; the specific gravity is 7.2; it is brittle, not easily fusible and is decomposed by hydrochloric acid, leaving a yellowish coloured powder. Very few minerals having a vitreous

or resinous lustre possess such high specific gravity; that is one of the best clues to its determination.

There is probably no mineral commercially valuable which takes so many forms, differing so radically in appearance, as the ores of tungsten. To all except the expert there is no connection except the unusual weight, between the black ferberite and the light-coloured and not infrequently white scheelite. Tungsten ores may occur in rocks of the most varied character—in quartz veins, in granite, or some of its modifications, also in pegmatite dikes, in ryolite, limestones and shales.

Tungsten ores are as a rule very brittle; they can be crushed to ¼ in. and then jigged, or screened through a 20 or 30 mesh screen, when nearly all the mineral can be saved. Owing to that and its high specific gravity it is possible to obtain a marketable product with hand appliances. Tungsten ores slime badly. Many gold mines should be looked over for tungsten minerals, as some of them may be profitably worked for tungsten which do not pay when worked for gold; in some cases a profit may be obtained from both metals. There appears to be occasionally an inverse ratio between the gold and the tungsten, when the latter content of the vein becomes low, the former may increase.

Europe.—Tungsten ores occur in many European countries, including Portugal, Spain, Great Britain, France and Italy. The largest output is obtained from Portuguese mines, second only to those of the United States. The ores occur mainly in the north of Portugal and in those portions of Spain bounding Portugal on the north and north-east sides. The Portuguese mines are situated in the province of Beira Baja, a few miles from the town of Silvares, not far from the Spanish frontier. The ores from many of the mines are conveyed to the coast and placed on board ship at Oporto. Wolframite ores occur in the Spanish provinces of Pontevedra, Coruna, Orense, Salamanca and Caceres. A lower grade of ore is also found in small quantities in the province of Cordoba. Exportation of wolframite ore commenced about 1903; there were difficulties in developing the industry, arising from the mountainous character of the country, the distance of the mines from the railroads, and the heavy expense of transporting machinery and fuel. Both the Portuguese and the Spanish ores are of high-grade quality, the analyses of the ores frequently average 60 and even more per cent. In the form of concentrates the average may be as high as 70 per cent. The wolframite from the provinces of Salamanca and Caceres is combined with arsenical pyrites. In some of the mines the two minerals have been found so thoroughly mixed that the arsenic may have to be burnt out to render the wolframite marketable. In other mines the arsenic is found separate from the wolframite; whilst in the provinces of Pontevedra, Coruna and Orense no arsenic occurs, the wolframite ores being mixed with tin. Up to the close of the last peace year, 1913, the British output of tungsten ore was a very small one, and as follows :—

	Tons.		Tons.		Tons.
1913 ...	217	1910 ...	301	1907 ...	406
1912 ...	196	1909 ...	414	1906 ...	342
1911 ...	270	1908 ...	294	1905 ...	216

For 1915 the British output of tungsten ore was 331 tons, distributed as follows :—

Cornwall, 310 tons, 68 per cent. metal; Devonshire, 8 tons, 6 cwt.; and Cumberland, 13 tons.

During the war years 1915–1916 we have imported tungsten ores from the colonies and have treated them in works provided for that purpose. (See page 509 of our issue of November 24, 1916.)

The United States.—The output of tungsten ore in the United States is the largest in the world, and has been as follows during recent years in short tons (2,000 lb.):—

	Tons.	£		Tons.	£		Tons.	£
1900	48	2,300	1906	928	72,680	1912	1,200	102,500
1901	179	5,775	1907	1,640	195,426	1913	1,525	133,437
1902	184	7,091	1908	671	47,907	1914		
1903	292	9,901	1909	1,619	127,993	1915	2,165	416,666
1904	740	38,333	1910	1,821	173,540	1916	3,200 (estimate)	1,898,000
1905	803	55,974	1911	1,139	84,996			

The production of tungsten ores in the United States fell off during 1914, in consequence of the steel works not requiring the usual quantity of ferro-tungsten. In comparison the demand and production during 1916 exceeded that of any previous year. For the first half of the year the output was approximately 1,600 short tons of concentrates, carrying 60 per cent. WO_3. For the whole year the output may have reached over 3,000 tons. Prices were at more than ten times their ordinary level. Ores are obtained from Colorado, California, Nevada, Arizona, and in small quantities from Alaska, Connecticut, Idaho, Missouri, New Mexico, South Dakota and Washington. In most other countries the prevailing mineral is wolframite; no other country can compete with the United States in the quantity of ferberite and scheelite produced; during 1916 the quantities were approximately as follow :—

	Tons.		Tons.
Ferberite ...	1,490	Wolframite ...	200
Scheelite ...	1,400	Hubnerite ...	185

In addition well over 2,000 tons were imported, mainly from Peru, Bolivia, Argentina, Brazil and Mexico, as the British embargo on the shipment of tungsten ores from every part of the Empire cut off all supplies from Burma, Australia and New Zealand.

The production of marketable concentrates of tungsten ores and tungstic acid in the United States is being increased to the utmost extent to meet the large demand, but it is realised that when peace is restored large foreign sources of supply, which are now cut off by the exigencies of war, will compete in the American market and tend to lower prices, foreign ores being cheaper than American. An effort is therefore being made to influence Congress to fix an import duty on tungsten ores and tungstic acid, so as to protect American enterprise and producers against the output of foreign mines, which are operated at a much lower cost, especially as regards labour.

The high price of tungsten has suggested to experts that ferro-molybdenum could be used as a substitute for ferro-tungsten. The tungsten belt of Colorado lies in Boulder county, near the Rollins pass. The country is well supplied with timber suitable for mining purposes; several railroads are within reach. The ore is a wolframite; a tungstite is also found carrying free sulphides of iron. Tungsten deposits were discovered in 1913 in California, a few miles west of Bishop Inyo county, but they were not worked until the summer of 1916. Outcrops of scheelite have been discovered at intervals over 15 miles of country. The ore is associated with garnet, epidote and quartz. The association of tungsten-bearing minerals with garnet is of great assistance to prospectors. In Nevada scheelite ore is being mined 22 miles south-west of Lovelock; the ore occurs as a deposit in garnetised limestone, at a contact with granite. Tungsten deposits have been known to exist since 1908 near Calabasas, Arizona, a station on the Nogales branch of the Southern Pacific Railway. In the Whetstone Mountains in Cochise county, Arizona, an unusual and interesting variety of wolframite occurs in the form of tungstate of manganese and iron. This mineral is found in a light-coloured granite, intrusive in mica-schist and limestone, near the line of contact.

Canada.—Scheelite occurs in Halifax county, Nova Scotia, Quebec and Ontario. Hubnerite is found in Cape Breton, and both wolframite and scheelite occur in the Kootenay district of British Columbia. The Nova Scotia tungsten veins are of the interbedded type, occurring in thin bands of slate between beds of quartzite. This scheelite is honey-yellow to pale reddish-brown in colour, coarsely crystalline, with distinct cleavage.

South America.—Tungsten ores occur in Bolivia, Peru, and the Argentine Republic, and are known to exist in Brazil. In Bolivia the principal deposits are in the provinces of Caluyo, Inquisivi and South Yungas; but the mineral is widely distributed in many localities. All three tungstates occur—wolframite, an iron-manganese tungstate; scheelite, the calcium tungstate; and hubnerite, a manganese tungstate. These ores carry from 20 per cent. to 50 per cent. of metallic tungsten. Many of the deposits are at a great height above sea-level, ranging from 13,500 ft. to 16,500 ft. So recently as 1910 about one-fifth of the world's production of wolfram was mined in the Argentine Republic; this wolframite is a tungstate of iron and manganese, ranging from 65 per cent. to 75 per cent. of pure wolfram. Deposits occur in the provinces of San Luis and Cordoba. The Hansa mines in the Argentine Republic can produce about 50 to 60 tons of tungsten ore per month. The total Argentine exports of tungsten ore from 1909 to 1913 inclusive amounted to 3,320 tons, an annual average of 664 tons. During the war year 1915 the total quantity exported was 158 tons, of which 135 tons went to the United States. During 1916 probably the whole of the output exported went to the States.

Peru.—Deposits of wolframite are being developed in the Conchucos district of the department of Ancash and La Libertad, discovered in 1910. The crystals have been described as being exceptionally pure, some assaying up to 72 per cent. tungstic acid. There is said to be very little iron or manganese and no tin in the ore. Other deposits have been found near Lircay, province of Angaraes, in the department of Huancavelica. Some of these ores contain 3 per cent. of tungsten trioxide, 25 per cent. of copper, and a considerable percentage of silver. The output includes hubnerite-tungstate of manganese, with 64 per cent. of tungstic acid, and wolframite ores, the concentrates containing from 64 per cent. to 68 per cent. of tungsten trioxide.

Asia.—Tungsten ore deposits are very widely distributed and are being worked in a large number of localities, including the Malay States, Burma, India, Japan, Korea, the Dutch East Indies, Indo-China and Siam. Tungsten is not found in defined deposits in the Malay Peninsula; the greater quantity is obtained in small quantities irregularly intermixed with tin ore and valueless material. Recent exports have been as follow :—1915, 291 tons; 1914, 261 tons; 1913, 225 tons. Most of this ore contained less than 65 per cent. tungstic acid. During 1915 407 tons were imported, and after treatment at separating works in the States re-exported. A limited quantity of wolfram is extracted from tin ores treated in the important tin-smelting works in the colony. Ores of tungsten have been discovered practically all over the Tavoy and Mergui districts, in Burma, also all along the coastal districts of southern Burma. The ores also contain tin, but wolframite is the main object sought for; the cassiterite is treated as a by-product, but occasionally the tin ore forms the larger percentage of the deposits. The first trial specimens of wolfram were shipped from this locality so recently as 1908, and in 1914 Burma produced 2,326 tons of tungsten ore, out of a total world's consumption of about 9,000 tons.

An important stage in the development of the wolfram industry of Burma was reached towards the end of 1916, when an electro-magnetic separator was installed at Tavoy. By means of this machine wolfram can be separated from magnetic ilmenite and monazite in mixed concentrates, leaving the non-magnetic tin ore and sand to pass over into a separate compartment.

Japan.—The output of tungsten ore in Japan is rapidly increasing. During 1915 the quantity exported exceeded 400 tons; for 1916 the output may be estimated at 1,300 tons. An exceedingly rich vein of ore was, it has been reported, recently discovered in a long range of hills in the Yamaguchi prefecture, which according to investigations made by Government experts has been described as the largest as yet found in the East, the ore being of excellent quality. The demand for tungsten has induced capitalists to open out and work deposits known to exist in Korea; the production is estimated to be 50 tons to 60 tons per month.

Australasia.—The leading tungsten ores, wolfram and scheelite, exist in considerable quantities in Australia, and many large deposits are known and mined in New South Wales, Queensland, South and Western Australia, the Northern Territory, Tasmania and New Zealand. In New South Wales wolfram and tin-stone are found associated in numerous localities, but up to some years ago it was frequently found impossible to treat the two minerals at a profit when they occurred in equal proportions, as their specific gravity is so nearly similar that they could not be separated by ordinary mechanical appliances. The difficulty has been overcome by passing the pulverised and dried ore under the poles of powerful electro magnets, the wolfram being sufficiently magnetic to be extracted and separated from the tin-stone. In the Northern Territory numerous well-defined wolfram reefs and leaders from 1 in. to 4 ft. in width have been located. In a number of instances the outcrops have been traced for half a mile. The Tasmanian ore is a wolfram and the New Zealand mainly a scheelite.

The selling value of tungsten is generally based on a percentage of pure ore or metal, say 50 per cent., the unit being 1 per cent. The term "unit" must be, however, used with care, or it may be misleading; thus 6*l.* 5*s.* per unit for tungsten ore by commercial usage would only be applicable to ore or concentrates carrying 60 per cent. WO_3 (tungstic acid), it would not apply to lower grades, such as 5–10 per cent. or 20 per cent. WO_3 ores. The iron tungstates (ferberite and wolframite) range in extra high grade to over 70 per cent. WO_3 content. Where manganese is present (hubnerite) in appreciable quantities the WO_3 content is reduced in proportion to the manganese increment. The calcium tungstate (scheelite) may run as high as 80 per cent. WO_3. For grades lower than 60 per cent. a graduated scale is occasionally used, setting forth the price unit for each per cent. content from 1 per cent. to 60 per cent. Thus when ore is selling at 2*l.* per unit it would be :—

60 per cent.	— 2*l.*	0*s.* per unit	= 120*l.*	per ton.
50 ,,	— 1*l.* 14*s.*	,,	= 85*l.*	,,
40 ,,	— 1*l.* 10*s.*	,,	= 60*l.*	,,
30 ,,	— 1*l.* 6*s.*	,,	= 39*l.*	,,
20 ,,	— 1*l.* 2*s.*	,,	= 22*l.*	,,
10 ,,	— 0*l.* 18*s.*	,,	= 9*l.*	,,
5 ,,	— 0*l.* 16*s.*	,,	= 4*l.*	,,

During 1916 prices rose to such an abnormal level that the schedule system was practically in abeyance. Prices during recent years have varied as follow :—

1912.—During the spring the price per unit was 1*l.* 11*s.* 3*d.*, and it then fell to 1*l.* 0*s.* 10*d.*, continuing at that level until December, when it rose to 1*l.* 3*s.* 9*d.*

1913.—During the spring of the last complete peace year the price per unit remained at 1*l.* 3*s.* 9*d.*, it then rose and during the autumn was 1*l.* 6*s.* 8*d.*, and continued at that price throughout the remainder of the year.

1914.—From January to August the price per unit was 1*l.* 2*s.* 6*d.*

1915.—The price per unit rose during the year, in

the autumn it was 2*l.* 15*s.*, and during the winter the increase continued.

1916.—There was a phenomenal rise in the United States, due to enormous demand and limited supply; in February the price per unit for 60 per cent. ore was 11*l.* 17*s.* 6*d.*; in March, 17*l.* 14*s.* 2*d.* to 18*l.* 15*s.* In April it was 17*l.* 3*s.* 9*d.* for 60 per cent. ore; 10*l.* 5*s.* 4*d.* for 25 per cent., and 9*l.* 3*s.* 4*d.* for 10 per cent. ore. During October and November the prices ranged from 3*l.* 2*s.* 6*d.* to 3*l.* 10*s.* 10*d.*, a remarkable contrast to the spring quotations.

COLONIAL ENGINEERING PROJECTS.

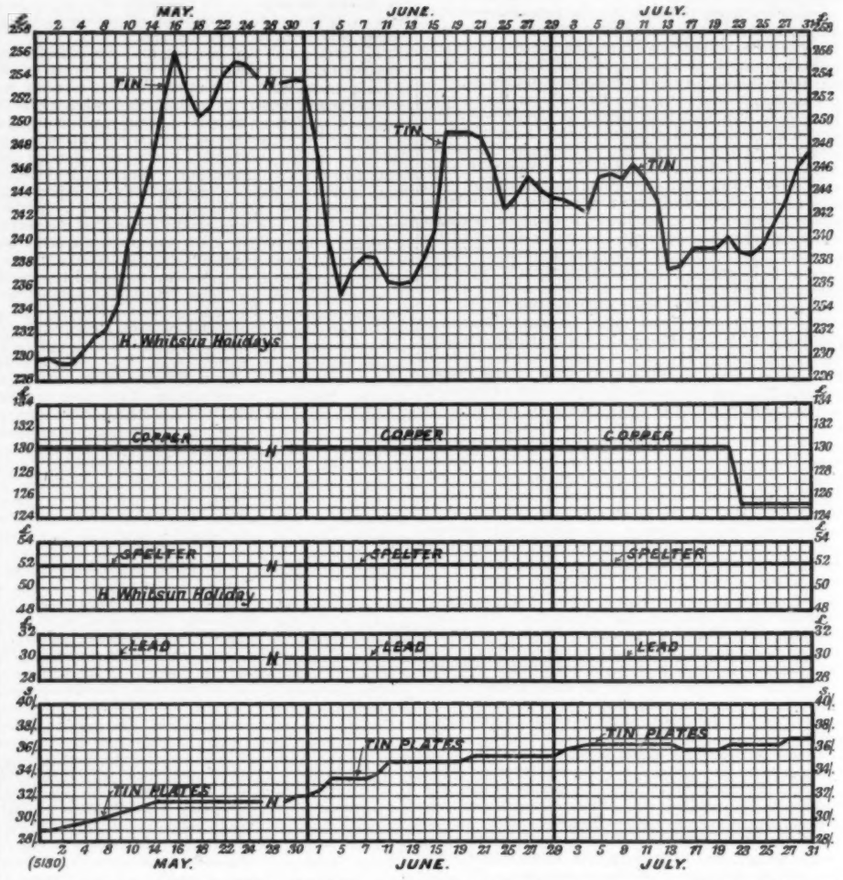
We give below a few particulars, taken from *The Board of Trade Journal*, concerning several colonial engineering projects. Further information concerning these can be obtained from the Department of Commercial Intelligence, 73, Basinghall-street, E.C. 2.

South Africa.—H.M. Trade Commissioner in South Africa reports, under date May 15, that he has recently visited various towns in the eastern portion of the Cape Province, and has been informed that considerable developments are pending in connection with water supply and sanitation in the localities mentioned below. Queenstown has a good water supply, and has recently installed a sewage disposal plant. A large part of the town is now sewered, and domestic installations are replacing the bucket system. King William's Town has ample water, but is deferring outlay on sewerage until after the war. Grahamstown is somewhat unfortunately situated. The town has hitherto depended on certain reservoirs, liberally supplemented by domestic rain-water tanks. The rainfall over the town's catchment area during the last three years has been very short, and if it had not been for rain-water supplies from their own tanks, the position of householders and of educational and other institutions would have been very grave. Of additional catchment areas available, none are really suitable for impounding water, but experts have been called in to advise as to obtaining supplies for the locality. The health authorities at Port Elizabeth have recently called attention to the urgent need for a thorough overhaul of both water supply and sanitary facilities, as in several towns in the district the water supply system combines irrigation of the surrounding lands with the provision of water for domestic and other urban use. At present there is only a bucket sanitary system in use in the locality. Outdshoorn water supply is good, though not sufficient to make a water-borne sewerage system possible. Here also local landowners have a claim for irrigation water. A comprehensive irrigation scheme is in contemplation in an adjacent district and this is likely to lead to extensive modifications of existing arrangements. East London (including the suburb of Cambridge): The municipal authorities have decided that a pumping scheme to obtain additional water from the Buffalo River is the only financially possible means of augmenting the water supply of their district. It is stated that when an efficient water supply has been obtained, a water-borne sewerage scheme will follow. According to the report of the city engineer, it is proposed to establish a new pumping station on the Buffalo River, at a point about 3 miles above the city's present pumping station. The station would be equipped with a modern plant, including a ram pump capable of raising 2,304,000 gallons of water per day of 24 hours. The water would be delivered through a 15-in. cast-iron main, 7,200 ft. long, to a proposed new impounding reservoir, the site of which is regarded as suitable as, generally speaking, rock has been reached at 4 ft. to 5 ft. below the surface. The capacity of the reservoir when full would be 254,368,940 gallons. As the water from the Buffalo River is often turbid, a settling tank, with a capacity of 1,000,000 gallons would be provided. Provision would be made for three filters, to deal with 1,250,000 gallons per day. Two service reservoirs have been provided for in the scheme, each 200 ft. by 110 ft. by 12 ft. deep, the combined capacity of which would be 3,000,000 gallons. A new 12-in. cast-iron main, 6 miles long, would be required to connect the new reservoir with East London. New 15-in. mains connecting the old pumping station with the new reservoir, and the new station with the old reservoir, would be required in connection with the scheme. Reticulation of new mains for supplying various districts and the wharves at East London is provided for in the scheme. It is suggested that when tenders are called for, alternative figures should be obtained for operating the pumping plant by (*a*) steam power, and (*b*) electricity. The cost of the whole of the works comprised in the scheme is estimated at (*a*) with steam-pumping plant, 148,281*l.*; and (*b*) with electrically-driven plant, 134,347*l.*

Reinforced Concrete Ships.—A San Francisco paper mentioned in a recent issue, says *The Marine Journal*, New York, the fact that a local firm of engineers was designing a ship, 330 ft. by 44 ft. by 31 ft., with a capacity of 4,500 tons, to be built of reinforced concrete. This is not a new idea, adds the New York journal, as a boat of reinforced concrete was built by a Frenchman in 1849, and is still in service, while other craft of concrete have been built from time to time since then. The concrete ship is only a further development of the concrete barge, or lighter, and such vessels have been in successful use for years. Since 1910 concrete barges have been built for use in the various sections of the Panama Canal. Recently concrete pontoons, 120 ft. long, were constructed there for service as landing stages for boats up to 65 ft. in length. Vessels which are more like ships than barges have also been built of reinforced concrete in Norway.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(*Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.*)



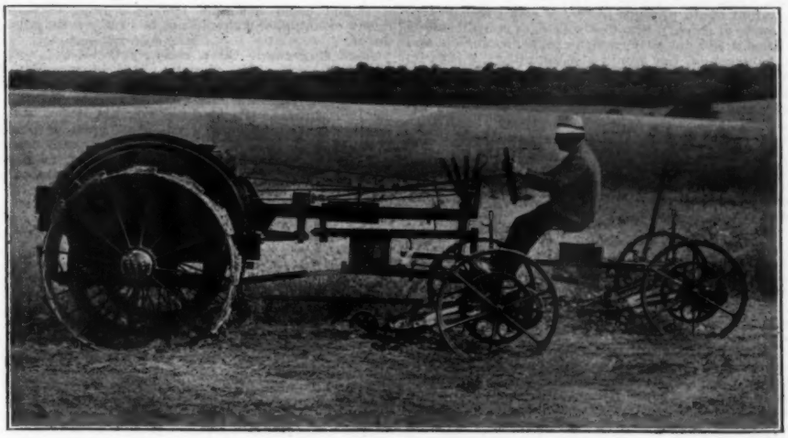
Note.—In the diagram above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton; the price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

Engineering and Electrical Data.—Through the courtesy of the British-Thomson Company, Limited, of Rugby, we have received a copy of a pocket-book issued by the General Electric Company, of Schenectady, New York. This is really a pocket-book—it will go into a waistcoat pocket. In its 80 pages it contains more—and more useful—information than we remember to have seen in any previous book of the same size. It is mainly electrical, but there is a good deal of engineering information useful to electrical engineers. In addition, there are a number of maps, and blank pages for memoranda.

The British Engineers' Association.—The fifth annual ordinary general meeting of the British Engineers' Association was held at Caxton Hall, Westminster, London, on Thursday, July 26, and was attended by a large number of representative members from many parts of the country. In moving the council's report, balance-sheet and income and expenditure account for the year ended December 31, 1916, which had been issued to all members, the chairman (Mr. Wilfrid Stokes) reviewed the work done by the association during the past year, and dealt with the action which it was proposed to take in future. The new memorandum and articles of association, which had been revised in accordance with the resolution passed at the extraordinary general meeting of the association on July 13, 1916, had received the sanction of the Courts, and were now operative. Mr. Stokes reminded members that the memorandum and articles had been revised in order to strengthen the relations between manufacturing engineers and those bodies and individuals with whom they are naturally brought into contact in the course of their business, as set out in the Manchester scheme for the organisation of the British engineering industry. He pointed out that much interest had been shown in the election of the new council, and for the 30 seats on the council about 90 members, including retiring members, were nominated in the various districts, a total of 1,369 votes being recorded. At the first meeting of the council, held the same day, Mr. Wilfrid Stokes was re-elected president, and the council now stands as follow:—President: Mr. Wilfrid Stokes. Vice-presidents: Mr. T. O. Callender, Sir John Cowan, Mr. Peter Denny, Mr. Herbert Marshall, Captain L. E. Mather, Mr. J. E. Thornycroft, Mr. Douglas Vickers. Members: Mr. Daniel Adamson (J. Adamson and Co.), Mr. H. Allcock (W. T. Glover and Co., Limited), Mr. H. Austin (Austin Motor Company, Limited), Mr. Stanley Brotherhood (Peter Brotherhood, Limited), Sir Edwin Grant Burls, C.S.I. (Vulcan Foundry, Limited), Mr. George Cradock (George Cradock and Co., Limited), Mr. Robert Goudie (Loudon Brothers, Limited), Mr. John Hemming (F. H. Lloyd and Co., Limited), Dr. G. B. Hunter (Swan, Hunter and Wigham Richardson, Limited), Mr. John Hunter (Sir William Arrol and Co., Limited), Mr. A. Jacob (British Aluminium Company, Limited), Mr. Christopher James (Joshua Buckton and Co., Limited), Mr. J. R. C. Kearns, (H. W. Kearns and Co., Limited), Mr. B. Longbottom (Electromotors, Limited), Mr. Hugh Lupton (Hathorn, Davey and Co., Limited), Mr. C. P. Martin (C. A. Parsons and Co., Limited), Mr. A. E. Owen (Rubery, Owen and Co.), Mr. Henry Steel (Steel, Peech and Tozer, Limited), Mr. T. Cuthbert Stewart (Stewart and Lloyds, Limited), Mr. H. J. Ward (J. and E. Hall, Limited), Mr. J. C. Ward (Edgar Allen and Co., Limited), Mr. A. P. Wood (the Lancashire Dynamo and Motor Company, Limited).

THE MOLINE FARM TRACTOR.

CONSTRUCTED BY THE MOLINE PLOUGH COMPANY, MOLINE, U.S.A.



The number of tractors competing for the farmer's selection is very great, while the varieties are numerous enough to make selection a matter of considerable difficulty. There are caterpillar tractors, tractors with one and with two driving wheels, with one and with two steering wheels, with all the wheels running on the land, and with one wheel in the furrow. Some tractors draw the plough or other implement by a chain, some have a plough built into their framework, and some are arranged to be bolted or pinned to the plough or other implement. Some will turn six furrows simultaneously, while some are limited to two. No doubt every type of tractor has its uses and excels under the conditions for which it was designed. The needs of the large farmer may well be met by one kind and those of the smaller farmer by another, while hilly and stony farms will require different types of tractors from flat and loamy land. The Moline tractor, which we illustrate on this page, is designed for the farmer of moderate means, who requires a machine which is adaptable to a large number of operations, such as ploughing, cultivating, harrowing, rolling, harvesting and self-binding. Further, it is designed to meet the present scarcity of labour, as one man can control both the tractor and the plough, lifting the shares and coulters at the headlands when the tractor is being turned. The plough can be replaced by a harrow or harvester, or by some other implement, the man in charge in all cases riding on the implement and not on the tractor, so that the various levers and controls are ready to hand, just as in a horse-drawn implement.

The Moline tractor has two opposed horizontal cylinders, 4¼ in. by 6 in., as in a Douglas bicycle, and gives from 10 h.p. to 12 h.p. on the belt. It drives through gearing and a differential on to two short shafts, each ending in a pinion which engages with an internal-toothed ring in one of the driving wheels, there being one speed forward and one reverse.

The crankshaft is 2½ in. in diameter, and the main bearings are 4½ in. and 5 in. long. The cams are forged solid with the camshaft, and are ground to shape. The valves, of nickel steel, are 2¾ in. in diameter. There is forced lubrication to all the bearings and to the connecting rod ends. The governor is enclosed and runs in oil. It can be adjusted by the man in charge to give any speed from ½ to 3 miles an hour. The transmission, differential and jack shafts are carried in Hyatt roller bearings.

The driving wheels are fitted with strakes, to give a grip on the ground. These can be removed for passage over roads, and can be replaced by spuds, if found more suitable to any particular land.

The motor, gear-box and wheels form a self-contained unit and the entire weight is available for adhesion. The motor is prevented rotating around the axle by a radius rod, which has a bifurcated end pivoted on two pins, one above and one below the axle. The driving wheels, with the motor, may be likened to the fore-carriage of a coach which is able to "lock," while the radius rod resembles the "perch." There is a toothed sector on the motor frame, and on the radius rod a pinion operated by a hand wheel. By aid of these the driving wheels can be steered to either side in a 16-ft. circle.

The plough, like the motor, is also a self-contained unit. It is connected to the radius rod by pins and bolts, and considerable latitude of adjustment is provided for. In connection with it there are two wheels carried on a cranked axle, and these wheels maintain the share and the mould boards at the right depth in the soil. On approaching the headland the man releases the clutch with his foot, and one of the wheels winds up a chain, which draws the wheels backwards. From the way in which the axle is carried the backward motion of the wheels lifts the mould boards clear of the soil and allows the plough to turn. The plough is fitted with levers to adjust the mould boards to the lie of the land, so that all may cut uniformly. There is also an adjustment to one wheel of the tractor so that it can run in the furrow, and yet maintain the machine horizontal. The overall width is 4 ft. 6 in., and the weight 25 cwt.

The tractor is constructed by the Moline Plough Company, of Moline, U.S.A., who are turning them out at the rate of 80 a day. It is imported into the country by the British Empire Motors, Limited, 115, Fulham Road, South Kensington, London, S.W.

Committee of Inquiry into the Utilisation of Irish Peat Deposits.—The Fuel Research Board, with the sanction of the Committee of the Privy Council for Scientific and Industrial Research, has appointed a committee of inquiry into the utilisation of Irish peat deposits. The terms of reference to the committee are as follow:—"To inquire into and to consider the experience already gained in Ireland in respect of the winning, preparation and use of peat for fuel and for other purposes, and to suggest what means shall be taken to ascertain the conditions under which, in the most favourably situated localities, it can be profitably won, prepared and used, having regard to the economic conditions of Ireland; and to report to the Fuel Research Board." Though the inquiries of the committee will ultimately lead up to the consideration of peat as a source of energy in central power stations, there are sound reasons why this aspect of the problem should be postponed to a later stage. On the one hand, the Fuel Research Board is already organising an extensive inquiry into the problems of fuel economy in connection with power production, and the results of this inquiry will supply the fundamental data and information which will be required when the time comes for the consideration of any wide scheme of development in Ireland. On the other hand, any schemes of development must be based on a more exact knowledge than is at present available regarding the selection of the more favourably situated bogs and the possibilities of winning and transporting partially dried peat to centres at which it may be converted into marketable products. It is obvious, therefore, that the inquiries of the committee are likely to be most fruitful if they are concentrated on the fundamental problems, for until these are settled no satisfactory progress can be made. The following appointments have been made to the committee:—Sir John Purser Griffith, M.A.I., M.Inst.C.E., Rathmines Castle, Rathmines, Dublin (chairman); Professor Hugh Ryan, M.A., D.Sc., F.I.C., University College, Dublin; Professor Sydney Young, D.Sc., F.R.S., Trinity College, Dublin; Mr. George Fletcher, Department of Agriculture and Technical Instruction for Ireland, Upper Merrion-street, Dublin; Professor Pierce Purcell, M.A.M.A.I., Assoc.M.Inst.C.E., University College, Dublin (secretary). All communications should be addressed to—The Secretary, the Peat Inquiry Committee, University College, Dublin.

MILITARY INFLUENCE ON MOTOR TRUCK DESIGN.*

By H. D. Church.

Motor trucks of American manufacture have played an important part in the present European War, but up to this time our general design has not been materially influenced thereby.

The conditions on the western battle front in Europe are such that large armies have been practically in the same positions for two years, and this fact, in conjunction with the first class French roads, has made it possible for the conventional design of American commercial motor trucks to render fairly good service.

In other words, the commercial motor truck of to-day is essentially a hard roads vehicle, and when used over such roads, would naturally not require any radical changes in design to meet military conditions.

In event of any fighting on American soil at any time for several years to come it is most improbable that similar conditions to those outlined above would exist. Our borders are so long that permanent trench fighting on a large scale is most improbable, and the roads in this country are far inferior to those of France or Germany. It follows, therefore, that a truck designed for satisfactory military operation in this country, which means for use in connection with mobile field operations over mediocre roads, or, in some cases, no roads at all, must necessarily be of a design differing in many respects from our present type of commercial vehicle. Furthermore, the design of such a truck is bound to be influenced by the widely varying climatic conditions found in the United States proper.

During the trouble with Mexico, in the past year, our army, for the first time, depended almost entirely upon motor transport, using quantities of the leading American makes of conventional commercial trucks.

From the standpoint of quick development of a suitable truck for American army use, it is most fortunate that the operating and climatic conditions were extreme, as the result was to define sharply those points wherein a truck designed primarily for commercial service would not satisfactorily meet our military needs.

The experience of our army with motor transport for the past several months has resulted in a vast amount of information as to desirable changes in design, and the army has been most willing to extend to the engineers of the various truck manufacturers every facility to gather first-hand information on army requirements for motor transport.

It is the writer's opinion that for American army transport purposes several different types of transportation will be required, according to topographical and road conditions:—

1. Mule transport.
2. Caterpillar tractors.
3. Four-wheel driven trucks.
4. Two-wheel driven trucks.

Each of these methods of transport will probably be used, as each of them has a certain field of operation which cannot satisfactorily be filled by the other types. It is probable that the majority of the transport work will be done with two-wheel driven vehicles, as, where the road conditions will permit of its passage, this type will haul materials in the minimum time and at the minimum operating expense. As the writer's direct experience has been largely with two-wheel driven trucks, this paper will be confined to consideration of that type, primarily of a nominal capacity of 1½ tons, this being the size which was most largely used in the military operations in Mexico.

Governors.—One of the first and most important points in connection with the design of a military truck is the absolute necessity for governors on the motors, not only to limit the maximum vehicle speed on high gear, but also to limit the maximum motor speed on any of the gears.

Experience along the border with trucks which had never been equipped with governors by their manufacturers, as well as with trucks on which the governors had been removed to obtain more power, proved conclusively that a governor is even more necessary for trucks in army service than for those in commercial service.

From personal observations made along the border, it is the writer's opinion that the constant maximum motor speed governor is the proper type. This type of governor not only keeps the maximum vehicle speed down to a point where durability is assured, but it also keeps the motor speed down at all times, so that it is impossible to shorten the life of the motor by excessive speed when running on any of the geared speeds in the transmission. This is an important consideration for soft road operation, where, if a governor which limits only the maximum road speed is fitted, there is a great temptation to the driver to run for long periods on second or third gear in the transmission with the motor racing, a practice which will materially shorten the life of the motor.

Governors must be thoroughly enclosed and sealed, to prevent their being tampered with without the knowledge of those in authority, and in order to obtain the best results should be extremely sensitive, without "surging." A sluggish governor cuts into the power curve of the motor too early on acceleration and too late on deceleration, and experience has shown that a snappy governor action can be obtained within speed limits of 4 per cent. on acceleration and 6 per cent. on deceleration,

---

* Paper read before the Cleveland Engineering Society (U.S.A.).

which will utilise the maximum amount of horse-power for a given maximum governed speed.

Ability or Tractive Effort.—Consideration of governors leads directly to the question of ability or tractive effort, both on high and low gears. To obtain the best results over soft road conditions, and *without* disconnection of governors, the average American commercial truck has insufficient high gear ability and far too little low gear ability successfully to pull its load through deep sand or mud or over extreme grades.

The average truck designed for American commercial service has plenty of ability on both high and low gears to handle successfully its load over hard roads and over the grades found in American cities, but the conditions of operation for army service in this country are much different.

The tractive effort required increases very rapidly with an increase in road resistance, and sand or soft going will not infrequently result in road resistances as high as 300 lb. to 500 lb. per ton, far in excess of anything ordinarily encountered in commercial service. When it is considered that the road resistance in pounds per ton on good asphalt is 15, on macadam 50 to 60, and over ordinary cobbles 130, the necessity for an increase in tractive effort becomes very apparent.

For American military purposes the low gear tractive effort should at least be sufficient continuously to turn the rear wheels of the fully loaded truck on dry asphalt with the truck itself stationary. Using a coefficient of friction between the tyres and a dry asphalt surface of 0.6 and a total rear end loaded weight of 7,600 lb. for a 1½-ton truck loaded to capacity, the low gear tractive effort necessary to meet these requirements becomes 4,560 lb.

Commercial truck practice now gives far lower figures. For example: the low-gear tractive effort of what is considered a powerful 1½-ton commercial service truck is only 2,600 lb. To carry safely the low-gear torque required to give 4,560 lb. tractive effort, the driving members throughout, from the gear train in the transmission clear back to the rear tyres, must be made heavier and stronger, which, of course, will result in an increase in chassis weight. From the standpoint of design it is probable that any such increase in low gear ability for military service, as outlined above, will cause more changes in truck chassis design than any other one requirement, the necessity for which became apparent during last year's experience on the border.

Motor Cooling.—The heat-dissipating ability of the average radiator was found inadequate, a serious matter at any time, and more serious in a country where water is scarce. With the thermometer standing at 110 deg. to 120 deg. in the shade and the truck using maximum motor power on low gear for long stretches, extraordinary motor-cooling ability is required. Probably an increase of 50 per cent. over average commercial practice would not be excessive, and a desirable provision would be a simple means for reducing the radiating area for efficient use in the cooler sections of this country.

When a truck is pulling along through heavy sand on low gear its speed is so slow that the air circulation through the radiator resulting from the movement of the vehicle can practically be disregarded. This means that the radiator fan must handle a large volume of air in order to keep the motor cool under these conditions. In the writer's opinion this is not so much a question of efficient fan design as it is of furnishing some means of driving which will keep the fan up to its normal operating speed. The belts used for driving the fans on the average commercial truck are not sufficiently powerful properly to meet this condition, and either the size or design of belt will have to be changed, or some positive drive provided for the fan.

This is an important point, for if the radiator design is such that it depends upon the fan circulation to give a certain cooling ability, the result is seriously affected if the fan does not at all times draw approximately the volume of air that it handles when its belt is new and tight. A feature of the radiator which should be given careful consideration is its mounting, which should be such as to minimise any strains in the radiator proper which are set up as a result of excessive chassis-frame deflection. Furthermore, the radiator should be of a type which has large water passages, is least liable to break under distortion, and which is readily repairable in the field.

Transmission Gears.—Army experience on the border clearly showed the desirability of four-speed instead of three-speed transmissions for military purposes. If the low-speed reduction ratio in a three-speed transmission is made great enough to give proper low-gear tractive effort, the steps between speeds become so great as to interfere with easy gear shifting. Furthermore, the four-speed gear-box has the very important advantage over a three-speed box for soft road service of always having a gear ratio more nearly adapted to any particular road requirement than can be obtained in a three-speed box.

It is probable that the gear ratios in a four-speed box for military trucks will be so arranged that second speed will be used for normal starting on hard road surfaces, and that the first speed, or low gear, will have a greater reduction ratio than anything which has been built to date. This high reduction ratio low-speed gear will then be in reserve for starting or running in deep sand or mud, or for climbing steep grades. In effect, such a combination of gear ratios would practically result in adding to a three-speed gear-box of the conventional ratios an extra low gear with an extremely high reduction ratio, to be used for starting or running in sand or mud or for climbing steep or soft grades.

Control Elements.—The desirability of standardising the control elements has been clearly indicated. When large fleets of trucks are operated by a single user, particularly if the trucks are kept in operation for more than 10 hours or 12 hours out of 24, two shifts of drivers are necessary, and there is bound to be a certain amount of shifting of drivers from one make of truck to another. Where drivers are called upon to drive different makes of trucks, they should be able to do so with facility, and much time would be saved, and better average operation assured, if the same motion of the driver's right or left hand or foot could produce the same result irrespective of the make of truck. Standardisation of controls along these lines would not only result in more economical and efficient operation, but would also simplify the instruction of drivers.

Wheels.—The use of all-metal wheels will undoubtedly receive careful consideration as a result of border experience, in spite of the fact that the wood wheels with which the majority of trucks were equipped gave remarkably good service. For desert running in the northern Mexican or south-western United States climates, any wood wheel, no matter how good, will eventually loosen in the spokes, and all-metal wheels are essential for durability in such climates.

On commercial trucks of 3 tons capacity and under steel wheels are not extensively used, due probably to the fact that for normal service wood wheels are perfectly satisfactory, and also because a set of steel wheels for a truck of 2 tons capacity or less will weigh approximately 125 lb. more than the corresponding wood wheels. For military service, however, which is bound to be extreme, any objection from the standpoint of slightly increased weight is more than offset by the necessity for durability under any climatic condition.

Wheel Gauge or Tread.—Wheel gauge or tread is most important when numbers of trucks of different makes and sizes are operated over the same routes on soft roads, and trucks for American army service ought to have a specified standard gauge in order that each different size or make does not have to break down a new track in the roadway.

If all sizes of trucks could be made to the present standard road gauge of 56½ in., such standardisation would be of the utmost value from a commercial as well as a military standpoint, as it would facilitate the operation of all trucks over soft country roads. Such a narrow gauge is impracticable for large trucks from 3 tons capacity and up, owing to constructional limitations. It would appear, therefore, that the best compromise from a military standpoint would be to ascertain how narrow it is practicable to make the gauge of the larger trucks and then to increase the gauge of smaller trucks to a point where their tyres will run within the tracks made by the wider tyres of the larger vehicles.

From a commercial standpoint this plan would slightly impair the usefulness of the smaller-sized trucks on soft roads, but if the gauge finally decided upon is not so much above 56½ in. that the wheels on one side can obtain no advantage at all from one of the 56½-in. tracks on the road, the objection is not serious, while any approach to a narrower gauge on present-day large commercial trucks would somewhat help their performance over soft roads. Such a standardisation of wheel gauge would be of immense value on trucks for military purposes, and, in the writer's opinion, would probably tend to increase the field of profitable operation for commercial trucks.

Final Drive.—It is evident that the best results will be obtained from some form of fully enclosed final drive, which should be so thoroughly enclosed as to retain lubricant, and to prevent deposit of fine dust or grit on any of the working parts.

Whatever form is used, either worm, internal gear, or double reduction, it should, in addition to the above requirements, be capable of efficiently and continuously transmitting the maximum low-gear torque of the vehicle without overheating, and give at least 10 in. road clearance with 36 in. diameter tyres.

A highly desirable feature would be the use of some form of differential which will automatically prevent one wheel from spinning if it loses traction, and which will still function as a differential when the truck makes a turn.

The torque-transmitting members throughout the rear axle, and through the entire driving train as well, should be able to stand, without overstressing, the sudden engaging of the clutch with the transmission in low gear, the motor running at maximum governed speed and the truck rear wheels locked.

Brakes.—The development of a braking system suitable for a military truck presents severe problems in regard to cooling. The brakes as used on our commercial trucks of to-day are not well enough cooled to stand up long under some military conditions, as for instance, handling the fully-loaded truck on a 3-mile descent on a hard road surface with grades running up to 25 per cent. and averaging 7 per cent.

Brakes as designed have sufficient power to hold the truck under such conditions, but will heat up so that the linings char slightly and wear rapidly. Water cooling is undesirable, and it is probable that some type of metal-to-metal brake will be necessary, which, while not as smooth in action as, and noisier than, the conventional brake faced with brake lining, will give greater durability under continuous application.

Dust Protection.—It is essential that thorough means be provided to keep dust and grit out of all working parts. Troubles from dust are more liable to result on trucks in military service than on those in commercial service, due to running in "fleets," or trains, over country roads.

Along the Mexican border, during the dry season, which means for the greater part of the year, there is an extraordinary amount of very fine, powdery dust, and a "train" of trucks running at 12 miles or 14 miles an hour will raise a dust cloud which is visible for miles. This fine dust is drawn into the motor cylinders through the carburettor intakes, acting as an abrasive on the pistons, piston rings and cylinder walls, and some is apparently drawn into the crank-case through the breather, mixing with the lubricating oil and causing undue wear on all working parts of the engine. Some form of separator or air strainer for both the carburettor and breather would be highly desirable, but it should be of a simple type, not requiring too frequent cleaning, and should not be of any form requiring water.

Road Clearance.—On a military truck the question of road clearance is of great importance. Not only should a minimum clearance of 10 in. at the centre of both the front and rear axles be maintained, but the clearances under the steering knuckle levers and the steering cross-tube ends must be as great as possible. Furthermore, unusually high road clearance is desirable under the chassis, midway between axles, to prevent contact with the ground when the truck is driven over a bank into a river bed or over a ridge.

Results of Frame Distortion.—To take care of excessive frame distortion, which is unavoidable when operating over rough or soft roads, the radiator, motor and transmission should be carried on three-point suspensions, and with clearances sufficient to obviate any possibility of their being themselves distorted. Provision should be made to protect the steering column from any binding from the same cause, and all connections between the rear axle and frame should be arranged to permit the maximum horizontal misalignment between the two without overstressing or breaking any of the connecting members. The gasoline tank mounting should also be carefully arranged to protect the tank from twisting strains.

Conclusion.—It is impossible, without writing an unduly long paper, to take up all the points in the design of our conventional trucks which will be more or less influenced by military use.

Many other points will be affected, such as motor-lubricating systems, carburettor design, steering gears, springs, body design and attaching means, &c., but the points discussed above are, in the writer's opinion, the ones which will require the greater changes in design to render our commercial trucks suitable for military use in this country.

The War Department has made a careful analysis of motor transport, and is now drawing up a specification to cover a desired design of two-wheel driven trucks for service with our army. It is improbable that any subsidy plan for military trucks, simiar to the English War Department subsidy plan, will ever be put into effect in this country.

In the absence of such a plan, it is probable that the United States War Department specification, when issued, will stand as a sort of master specification for American truck manufacturers, in that, as they bring out new models from time to time, they will incorporate in the design such features specified in the War Department specification as will not detract in any way from the commercial value of the truck, and, at the same time, so design the other parts that with minimum change modifications could be added to meet the balance of the specification. If this procedure be followed, the War Department will eventually be able to purchase, at comparatively short notice, trucks which much more nearly meet its requirements than anything on the market to-day; and furthermore, many of the features found necessary from army experience on the Mexican border will, if incorporated in our commercial trucks, materially enlarge their operating field.

Tests to Determine Properties of Alloys.—We read in *The Electric Railway Journal* that the engineering experiment station of the University of Illinois has just completed another series of experiments to determine the magnetic and allied properties of alloys of iron and other metals. In 1915 experiments with iron-silicon alloys disclosed some remarkable properties which make those alloys superior to any other material for use in certain electro-magnetic machinery. These experiments were followed by others dealing with iron-aluminium alloys melted in vacuo, which have shown that aluminium, like silicon, greatly improves the magnetic properties of the metal, and also that aluminium imparts to the metal a greater toughness than silicon.

Fire Tests of Ferro-Concrete.—Having conducted fire tests of ferro-concrete in 1910, the Materialprüfungsamt of Gross Lichterfelde, near Berlin, undertook new tests in 1914–15, on which Professor M. Garg has recently reported in the publication of the "Deutsche Ausschuss für Eisenbeton." Two houses were erected, 4 m. by 4 m., 8 m. high, the chief materials being ferro-concrete prepared either with crushed granite or with crushed basalt. The particular points investigated were: resistance of the concrete to internal fires, heat transference through the concrete, strength of the ferro-concrete structure before and after the fire, and behaviour of the structure during demolition. The report is not available, but from the *Schweizerische Bauzeitung* of May 19 we see that the houses stood the repeated, severe tests surprisingly well, better even than experts expected. The stairways of ferro-concrete and also of artificial stones proved excellent, and the mechanical properties of the iron were hardly impaired, although the temperature of the iron rose to 350 deg. C. The one unsatisfactory and, so far, unexplained feature was that fairly big pieces of hot granite-concrete sometimes flew off with almost explosive energy. This point is to be further investigated in the experiments, which have already been resumed.

THE SOCIETY OF CHEMICAL INDUSTRY.

(Concluded from page 89.)

WE conclude our notice of papers brought before the annual meeting of the Society of Chemical Industry and Congress on the Progress of Applied Chemistry, held at Birmingham in July.

"*Synthesis of Ammonia and its Oxidation to Nitric Acid.*" Dr. Edward B. Maxted gave an account of the work he and his collaborators have undertaken toward establishing a synthetic ammonia industry in Great Britain. The works of the Badische Anilin- und Sodafabrik at Oppau, he stated, were said to produce 1,000,000 tons of ammonium sulphate (calculated as sulphate ?) per annum, but particulars were not published. Dr. Maxted was also guarded in his statements, of course. The first step was the choice of methods for manufacturing the two gases, nitrogen and hydrogen. The formation of ammonia by the aid of catalysts was extremely sensitive to the presence of traces of inhibitive substances which interfered with the catalysis, and that consideration excluded the use of directly-produced mixtures of N and H, because they generally contained carbon monoxide. Hence N and H had to be made separately. The nitrogen they had found easiest to isolate from air by the Pictet process. Air cooled by exchange and other means down to—but not below—its liquefying point was injected, as gas at approximately atmospheric pressure, into a vertical separating column (Fig. 1) in which a number of horizontal plates were arranged, over which liquid nitrogen was flowing down; the oxygen in the air was condensed and mixed with the liquid N, and was fractionated, so

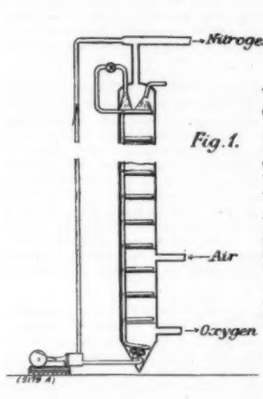
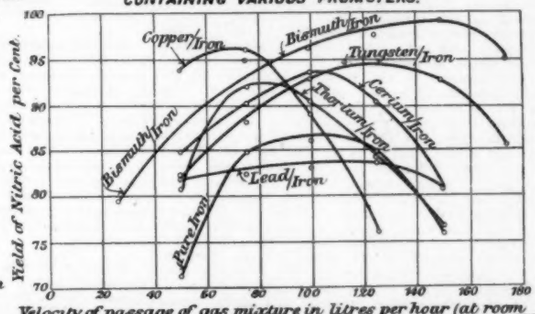


Fig. 1.

Fig. 2. OXIDATION OF AMMONIA. RELATIVE EFFICIENCY OF IRON CATALYSTS CONTAINING VARIOUS PROMOTERS.



Velocity of passage of gas mixture in litres per hour (at room temperature) per c.c. of free space in catalyst chamber. Temp. 700°C. Each c.c. of free space = 20 sq. cm. of catalytic surface.
(5178 B)

that practically liquid O collected in the bottom of the column, while gaseous N ascended. Thus only one-fifth of the air—the oxygen makes up one-fifth of the volume—was liquefied; only a small fraction of the N also underwent liquefication, in order to effect the separation. This was done in two ways, first by a slight compression in closed coils lying in the oxygen reservoir and on the plates, the pressure in the coils being adapted to the temperature in the respective portion of the column; at the top of the column, where the temperature was − 196 deg. C., a very slight increase in pressure would produce liquefication, while near the bottom, at −182 deg., additional pressure of several atmospheres was required. Losses of cold due to radiation and imperfections of exchange were compensated by the liquefaction (by expansion) of a further quantity of nitrogen; this was the second source of the separating liquid referred to. Their installation produced 400 cub. m. of N and 100 cub. m. of O per hour, and had proved extremely satisfactory, both as to the purity of the gases and low power consumption.

The purity of the hydrogen was the key to the economical synthesis. Electrolytic hydrogen was too expensive. When water-gas and steam were passed over activated iron oxide as catalyst, the reaction $CO + H_2O \rightleftarrows CO_2 + H_2$ took place, but it was never complete, and even with large excesses of steam some CO was left in the hydrogen and could not be removed by the ordinary purifiers, though it could be removed by treatment with calcium carbide or by compression on to heated soda lime, when formates were produced. As the vapour pressure of CO was considerable even near its freezing-point, the preparation of H from water gas by low-temperature separation was equally difficult. The objection applied also to the intermittent hydrogen process, when iron was alternately steamed and reduced. At high temperature CO decomposed—$2CO \rightleftarrows CO_2 + C$; the C was deposited on the iron during the reducing phase and reacted with the water gas in the next steaming phase: $C + H_2O \rightleftarrows CO + H_2$. As a consequence the intermittent-process hydrogen as a rule contained 1 per cent. or 2 per cent. of CO. They had, however, succeeded in improving the intermittent process by reducing, not with water gas, but with a mixture containing enough CO_2 to prevent any deposition of C. This hydrogen was quite free from CO and also from N, without the use of other purifiers than iron oxide and lime: for the ammonia synthesis the removal of the N was not essential, of course, but it was for the hardening of fats, *e.g.* Their hydrogen was of a purity of 99.9 per cent. and above.

The combination of N and H, which generated heat, required high pressure—they had found 180 atm. most suitable—and a catalyst. Apart from the platinum metals and from uranium—which was difficult to isolate and difficult to regenerate, and very sensitive to traces of water vapour—iron was a good catalyst, and its efficiency could be increased by the addition of small quantities of other bodies or promoters; several of these were simultaneously added to the iron in Germany. As regards the rate of the reaction, Dr. Maxted gave the following figures for the time of contact between catalyst and gas mixture, the resulting percentage of NH_3 in the gas, and the yield of ammonia in kg. per hour calculated per cubic foot of catalyst space: time 13, 26, 105 seconds, 18 minutes; ammonia, per cent., 0.8, 1.4, 3.1, 3.7; yield, 6.46, 3.03, 0.78, 0.89 kg. The catalyst used was described as iron-potash; the ammonia was assumed to be totally removed from the circulation by employing a refrigerator at almost the liquefaction temperature of ammonia (− 77 deg. C), and the temperature of the reaction ranged from 650 deg. down to 600 deg., in different parts of the catalyst chamber. The economy of the process depended much more upon the efficiency of the heat exchange and upon the complete elimination of the ammonia formed than upon the power absorbed, and the maximum yield of ammonia was not in itself decisive. The gases were heated, passed through the catalyst, and then cooled to liquefy the ammonia formed; the construction of the exchangers was therefore of primary importance. As, further, the first portions of ammonia were more rapidly formed than successive increments, a complete removal of all ammonia formed was desirable before repassing the gas through the catalyst. The removal of gas, *i.e.*, the temperature in the refrigerator, was influenced by the gas pressure of the synthesis; at 0 deg. C. and at 150 (or 200) atm. 2.7 (2.0) per cent. of the ammonia were left in the gas; at 60 deg., 0.13 (0.1) per cent. The retorts in which the synthesis was carried out had to stand high pressure almost at red heat, and were, moreover, exposed to deterioration by the ammonia. To overcome the pressure difficulty the reaction vessel was surrounded by nitrogen at the high pressure of the mixture inside, and the whole retort, with its strong outer walls, was placed in a pit out of doors; when a reaction vessel burst, which did happen, it split without projecting fragments.

As the reaction between the combining N and H developed heat, the heat to be supplied had practically only to make up for radiation and for the deficiencies of the heat and cold exchanges. Yet the choice of a method of heating was by no means easy. Electric heating had its drawbacks, and, as in Germany, Mr. Maxted injected a small amount of air into the catalyst chamber in such a way that the requisite reaction temperature was reached and maintained by internal combustion. With that method the retorts could be simple in construction, but there might be explosions—distinct from the bursting just mentioned—if the air should accumulate unburnt until rich enough in oxygen. Without giving particulars, Dr. Maxted said that their method seemed to combine simplicity with safety.

As regards the economic side, 5¼ tons of fuel sufficed per ton of ammonia for the production of the gases and the power needed for all the processes; the labour factor was small, but the plant expensive, and the cost of synthetic ammonia should be about 10*l.* or 12*l.* per ton in this country. The ammonia produced was mostly bound by acids (as a rule as sulphate by sulphuric acid and by interaction with calcium sulphate), or it was oxidised to nitric acid. This acid might itself serve for absorbing other ammonia; the resulting ammonium nitrate was very valuable and contained a very high percentage of nitrogen; against that was its deliquescent character.

Passing to the oxidation of ammonia by combustion with air in presence of a catalyst, Dr. Maxted said that three methods were in use:—(1) Ostwald used a plug of platinum covered with platinum black, and attained a yield of 90 per cent. and more; the temperature regulation was difficult, however; the Ostwald patents had now expired; (2) oxidation by passing the ammonia through electrically heated platinum gauze; how this simpler method is carried out at Stolberg, near Aachen, we described on page 440 of our issue of November 3, 1916; (3) oxidation by means of base-metal catalysts. On this third method Dr. Maxted gave some interesting information. He used iron, to which promoters were added, and not only air as such, but also air enriched in oxygen or oxygen itself; the increased cost of material was amply compensated for; 10 volumes of air per volume of ammonia were required, and they had obtained 96 per cent. of the theoretical nitric acid in experiments. At 700 deg. C. a very short time, a small fraction of a second, sufficed for the actual contact between the ammonia and the catalyst, and short contact was indeed desirable to avoid re-decomposition. Plotting the yield of nitric acid in per cent. against the time of contact in second (Fig. 2), Dr. Maxted found with contacts of 0.03, 0.02, 0.015, 0.012, 0.10 second nitric acid yields of 71, 82.5, 83.5, 82.5, 75 per cent. with iron itself. The figures were very similar with certain alloys (the preparation and composition were not stated) and the yields sometimes still higher, *e.g.*, with iron-bismuth, 0.06, 0.02, 0.015, 0.012, 0.01, 0.0086 second, gave yields of 78, 90, 92, 93.4, 94.6, 91.0 per cent. Iron to which cerium, thorium, tungsten or copper had been added was more efficient than iron itself. On the other hand, antimony did not behave like bismuth: owing to the volatility of the antimony, probably, its curve differed little from the iron curve after attaining a higher maximum. The addition of lead flattened the curve out curiously, *i.e.*, the catalytic action depended little on the time of contact; potassium, calcium, zinc, and manganese decreased the efficiency of the iron, uranium had little effect. In most cases a very short contact of about 0.01 or 0.012 second proved the most profitable; the catalyst chamber could hence be small, and the gases be sent through it at velocities of 80 or 100 litres per hour per cubic centimetre of free space in the chamber, those figures being reduced to room temperature; each cubic centimetre of free space corresponded to 20 sq. cm. of catalytic surface. Dr. Maxted concluded by estimating the comparative costs of the three chief methods for the fixation of atmospheric nitrogen, as nitric acid: this process; the arc process (Birkeland-Eyde and others); and the indirect fixation by way of calcium carbide, cyanamide and ammonia. The kilowatt-year, he estimated, would yield 830 kg. of nitrogen by the synthetic ammonia process, 380 kg. by the cyanamide process, and 130 by the arc process. The labour and plant items modified these figures slightly.

In another paper on this subject, "*Manufacture of Synthetic Nitrates by Electric Power*," Mr. Kilburn Scott described his three-phase furnaces; the comparative cost estimate of the second part of his paper was decidedly in favour of his own process as superior to the indirect process found suitable for taking off-peak and off-season loads.

"*Some Sources of Benzene and Toluene for High Explosives.*" A paper of this title by Mr. T. F. E. Rhead, of the Central Laboratory, Birmingham gas department, dealt in its several parts with various aspects of the problem which have repeatedly been noticed in our columns. Mr. Rhead distinguished four main sources: (1) synthetic, catalytic and electric processes—hardly advanced beyond the experimental stage so far; (2) crude petroleum containing benzene and toluene in the uncombined state; as to this, not unimportant group, which Mr. Rhead merely mentioned, we should refer our readers to recent comments on the proceedings of the Institution of Petroleum Technologists and other articles, dealing also with natural gas as a source for benzene, &c.; (3) the carbonisation of bituminous coal; (4) the cracking of petroleum oils. A certain amount of cracking, Mr. Rhead pointed out, was always going on in the retort, and that depended upon the position of the coal in the retort; unless a mass of coal were near the ascension pipe in a horizontal retort, the gases liberated would remain for some time in contact with hot coke and walls. A temperature of 700 to 750 deg. C. was recommended for a maximum yield of benzene and its homologues; but that meant something like 1,250 deg. C. on the outside of the retorts, to force the heat through in reasonable time, and hence partly the common opinion that high-temperature carbonisation favoured benzene formation. According to Cobb and Hollings, benzene was not rapidly destroyed by contact with hot coke unless the temperature rose to 1,100 deg.; but there was considerable destruction in the retorts. In deciding the scale of merit of horizontal and inclined retorts, coke ovens, and intermittent and continuous verticals, when depletion of benzene from coal gas was planned, the lack of a ready test for benzene in gas had been in the way. Mr. Rhead described his device for this purpose in his appendix, and apparatus for the extraction of benzene (by Dr. Lessing), and for toluene estimation (by Dr. Bowrey) were noticed in our issues of February 9 and June 22, 1917. Mr. E. W. Smith (at the Birmingham gas works) had quite recently carbonised, in horizontal retorts, along with coal, several substances—pitch from coal tar and Mond gas, petroleum residue and bitumen—for the purpose of raising the benzol content of coal gas; an increase had been obtained (except with the coal-tar pitch, which was already cracked), but as only a small percentage could be carbonised at the time, the process did not appear profitable. Carbonising the coal with lime (Rollason and Stevenson) and other processes had been tried, so far not with pronounced success apparently. As regards petroleum cracking, Mr. Rhead referred to Rittman and Egloff, and quoted Egloff's diagram of the course of the formation of aromatic hydrocarbons from paraffin base distillates—high and low boiling-point paraffins → low-boiling paraffins and unsaturated hydrocarbons → naphthenes, polymethylene → aromatic hydrocarbons (benzene ← toluene ⇆ xylene, toluene further yielding naphthalene) → diphenyl → diphenyl benzenes → triphenylene → carbon and

hydrogen. The manufacture of carburetted water-gas was essentially an oil-cracking process, and good quality benzene and toluene could be produced by washing this gas. At Birmingham they had obtained 3.27 per cent. of the oil as benzene and 2 per cent. as toluene, not seriously contaminated with paraffins, and this source was no longer ignored over here. Egloff, experimenting with a Lowe carburetted water-gas plant, had pointed out that in the United States more than 8,000,000 gallons of benzene, 7,000,000 gallons of toluene, and 1,000,000 gallons of xylene might be gained yearly in this way.

"*The Artificial Silk Industry.*"—Mr. Leonard P. Wilson, of Messrs. Courtauld, Coventry, gave much instructive information in this paper. Although a great deal of valuable research had been done, he stated, both here and abroad, since 1885, commercially very little was achieved over here in the past century, whilst Hilaire de Chardonnet began manufacturing artificial silk at Besançon in 1891, and 4,000 lb. of silk had been made by his process daily before anything was done on an industrial scale in this country. Chardonnet first squirted his solution of guncotton in ether-alcohol into water; in the later dry spinning process the viscous solution was passed through a number of fine glass nozzles into air, and the threads were wound on spools with a fast backward and forward traverse motion to keep the threads separate; the whole machine was enclosed, and the warm damp air was subsequently passed through a spray of amyl alcohol to recover the solvent. The objections against Chardonnet's cellulose nitrate—liability to gradual decomposition, inflammability, difficulty of dyeing—had partly been met by denitrification; but the denitrification was not complete, and it reduced with the weight also the strength of the product. Up till 1907 Chardonnet processes had been very successful on the Continent, though never here; at present the Tubize works in Belgium seemed to be the only ones kept working. Various modifications had been tried. The first successful rival had been the cuprammonium process, notably that of the Vereinigte Glanzstoff Fabriken, of Elberfeld. All cuprammonium processes started from cotton—other cellulose appeared to be unsuitable. The cotton was repeatedly treated with weak caustic soda at 2½ atmospheres, bleached, washed and beaten before being dissolved in the cuprammonium mixers. This solution was prepared by filling a large iron vessel with copper turnings and keeping them covered with ammonium at 4 deg. C. for 24 hours while blowing air into the solution. The mixing of the wet cotton and the solution and the subsequent filtering had to be effected at low temperature, below 5 deg. C.; otherwise copper was thrown out, and spinning became impossible. As in the Chardonnet process, the liquid was squirted through glass tubes of 0.1 mm. bore into some coagulating liquid; this was first sulphuric acid, then caustic soda, finally glucose. The glucose reduced the copper in the thread and deposited it as a reddish oxide mud, whilst the acid bath dissolved the copper, producing a blue solution in which any broken or faulty threads were invisible. The spinning was done on glass bobbins in acid; twisting the thread followed. Mr. Wilson also gave details of the modification of this process which Thiele had tried at Yarmouth, though the modification had not the success it appeared to deserve.

The third type of process, the viscose process, was entirely English in origin and development. The raw material was also cellulose, but in the form of wood, chiefly Norwegian spruce. The process was based on the discovery, made by Cross and Bevan and Beadle, in 1892, that cellulose, treated with caustic soda and carbon disulphide, gave a thick syrup of golden-brown colour, chemically cellulose xanthate, which they named viscose. The first viscose silk works of this country were erected by Messrs. Courtauld at Coventry, in 1904; on the Continent works had been started before that, and other silk works had taken up the new process; there were now about 30 viscose silk works altogether. The wood was first treated with calcium bisulphite, as in making paper pulp; the pulp sheets were mercerised in caustic soda, and the expressed alkali cellulose was ground into crumbs, which were matured; the maturing, which was an oxidation, was accelerated by the aid of sodium peroxide and by hydrates of iron or nickel as catalysts (Courtauld, Glover and Wilson patent). Treated with carbon disulphide the matured cellulose gave sodium xanthate $C_6H_9O_4 . NaS . CS$, which by successive hydrolysis broke down into cellulose hydrate, becoming at the same time more and more insoluble in water; the spinning took place at some stage, adjusted to the different purposes, before the hydrolysis was complete. The jets of soluble ammonium xanthate were forced through nozzles of platinum or other metals into ferrous sulphate, sulphuric acid, glucose, zinc chloride, &c., which made the threads insoluble and prevented their sticking together; they were spun on glass bobbins or in the Topham centrifugal box. In the latter case the thread passed through a vertically reciprocating tube into a circular box rapidly rotating on a vertical spindle; the centrifugal force threw the thread to the side of the box, where it built up an annular cake, the twist being given to the thread by the revolution of the box at several thousand turns per minute; the removed cake was afterwards reeled into skeins, which were washed, freed from sulphur, &c., bleached and dried. The thread was then ready for the textile works. Mr. Wilson briefly referred to the use of other cellulose products, ethers and esters, and of other materials, and to the difficult chemical analysis and identification of the various cellulose products, especially in mixed materials; he explained these tests with the aid of photomicrographs from his firm's laboratory. The tenacity of silk was very important; wet artificial silk in particular had not anything like the strength of natural silk, but great improvement had been made in the viscose during the past ten years. As commonly sold artificial silk had 11 per cent. humidity. The hundreds of tests, physical and chemical, needed in the works were of great variety. As to the importance of the general problems we should also refer our readers to the recent Royal Institution discourse by Mr. C. F. Cross (see ENGINEERING, March 7, 1917, page 228).

Two papers referred to rubber research. Mr. B. D. Porrit, in "*Scientific Needs of the Rubber Industry*," pleaded for co-operation by the universities and industries, and research on the lines done by the Rubber Growers' Association, and the Agricultural Department of the Federated Malay States and the Imperial Institute, the latter working in conjunction with the Government Agricultural Department of Ceylon. Few rubber firms were able lightly to face the expenditure of a purely research laboratory, and many works even now dispensed with the services of a chemist.

The papers on "*The Chemistry of Vulcanisation*," by Dr. D. F. Twiss, of the Dunlop Rubber Company, proved how obscure the rubber problems really remain. Cold vulcanisation, he said in his long critical review (with excellent literature list), was generally ascribed to the formation of the addition product $(C_{10}H_{16})_2 . S_2Cl_2$ between the colloidal hydrocarbon and the sulphur chloride, hot vulcanisation by means of sulphur similarly to the compound $C_{10}H_{16} . S_2$; a reversible solution process accompanied the reaction. But the theory that vulcanisation was merely adsorption, not chemical combination, had been revived by Wolfgang Ostwald in 1910. Dr. Twiss certainly believed in compounds; there were reversible adsorption products, however (methyl violet and charcoal, *e.g.*), and the most recent Russian researches, suggesting deaggregation of the rubber, followed by a polymerisation, advocated intermediate standpoints—if we may say so for brevity's sake. The changes in the properties of rubber seemed rather to follow combination, not to accompany it; the compound was certainly present only in a few per cent., and the vulcanised rubber was probably a solution of the compound in the rubber. How the inorganic and organic accelerators really accelerated the rate of the vulcanisation was not understood. Discussing their mode of action at length, Dr. Twiss stated that he had experimented on the possible influence of the two modifications of molten sulphur, yellow $S\lambda$ and brown $S\mu$, of which only the former was soluble in carbon disulphide; the two modifications slowly passed into one another, but alkalis favoured the formation of $S\lambda$ and acids that of $S\mu$. He had not found any noteworthy difference in the vulcanisation rates of the two sulphurs, however, though Dubosc had attributed the particular efficiency of organic accelerators to their producing amorphous sulphur. It seemed more likely that some organic substances were good accelerators because they acted as solvents and blended well with the rubber. Dr. Twiss had obtained particularly good results with glycerol, in which he dissolved caustic alkali or organic substances. As regards the variability of plantation rubber, in which one might expect more uniformity than in wild rubber, he pointed to the work of Eaton and Granville (in Malaya), according to which the serum of the coagulum was washed out of plantation rubber, whilst in wild rubber the serum could mature for several days; this maturing decomposed the protein matter in rubber (Stevens) into organic bases which were good catalysts. On the other hand Dr. Twiss remarked that accelerators worked equally well with rubbers from which the proteins had been removed. There had been great activity in vulcanisation research of late. One can only agree with Dr. Twiss that much more research is needed.

In giving a resumé of "*The Present Position of the Activated Sludge Process*," Mr. E. Ardern described the installations at Davyhulme and at the Withington works, Manchester, at Salford, Worcester, Stamford (Lincolnshire), and in several American plants. We explained the general development of sewage aeration and activated sludge processes a few weeks ago in our issue of July 6, referring to the work of Mr. H. W. Clark at Lawrence, Mass., and of Mr. Ardern, Dr. Fowler, and others at Manchester, &c., and briefly describing most of these and other plants, and we further published in our issue of July 13 an illustrated description, by Mr. T. Caink, of the installation at Worcester. Mr. Ardern drew attention to a novel feature of the Davyhulme installation—the mechanical arrangement of an automatic pulsating air supply. This patented device was due to Messrs. Jones and Attwood, who had installed most of these plants mentioned. Attached to each air pipe serving a row of diffusers was a mushroom valve, operated by a diaphragm receiving its air pressure intermittently from one of a series of pilot valves; the latter were operated from a camshaft turned by an air wheel immersed in oil; as a rule each set of diffusers received air for 5 seconds at intervals of 10 seconds. In his summary Mr. Ardern recommended continuous-flow systems for large-scale operations; he considered that most designs, so far, had failed to a certain extent as to settlement tanks and return of the sludge to the aeration chambers; England preferred porous diffusers, America apparently perforated air pipes. He touched upon the difficulties caused by grit and fat and on the greater difficulties of dewatering and drying the sludge, but said very little about the recovery of nitrogen from the sludge, as to which some experts have been so sanguine. At Wolverhampton Mr. W. Clifford had the whole of the sludge piped direct to farm lands. Of course this was not always possible, owing to the position of the works, but it offered the advantage that the bacterial content of the sludge would be maintained, and thus in addition to the food value the soil would receive whatever advantage was due to bacterial inoculation.

The paper by Mr. J. E. Fletcher on "*The Superheating of Slags and Metals during Refining, Smelting and Alloying Operations*" will be noticed on an early occasion.

CATALOGUES.

Belting.—A belting made of layers of fine flexible leather joined by interlapping and sewing, and finished to an even thickness with strengthened edges, is described and illustrated in a catalogue by Messrs. John Tullis and Son, Limited, St. Ann's Works, Glasgow. It can be supplied endless if so ordered. There is a full range of sizes in four thicknesses, from $\frac{1}{16}$ in. to $\frac{1}{4}$ in., and all usual widths from 1 in. to 40 in.

Carbons.—The Electrical Engineering and Equipment Company, Limited, Bank Buildings, 109, New Oxford-street, London, W.C., send a catalogue of carbon manufactures for lighting, welding, brushes, battery rods and plates, contacts of all kinds, tubes for chemicals, electrodes for furnaces and carbon packing for high-speed engines. Useful data, measurements and technical information are given, including a series of curves characteristic of the various grades of brushes.

Motor Cars.—American petrol and electric cars and vehicles for 1917 are listed in a trade publication issued by the American Automobile Chamber of Commerce, 7, East 42nd-street, New York. About 200 cars and vehicles made by 70 firms are tersely described, the particulars embracing price, seating capacity, wheels, tyres, brakes, engine, gearing, and lubricating, cooling, lighting, &c., systems. An illustration of the general appearance of each car is also given.

Case Hardening.—Messrs. David Brown and Sons, Limited, Huddersfield, have put on the market a case-hardening compound which they have made after much practical experiment for their own gear work. Work pieces packed in a box of 12 cub. in. volume will, starting with full muffle heat and cold box, acquire a case $\frac{1}{32}$ in. deep in 2½ hours, with a temperature of 900 deg. C. The catalogue gives useful practical information and instructive illustrations of test pieces and examples of case-hardened work.

Riveting Machines.—The John F. Allen Company, 372, Gerrard Avenue, New York, send a catalogue of portable riveting machines. There are three types—for structural work, boiler making and lattice work—with a considerable range of sizes in each type. The power is applied through compressed air cylinders, which are adaptable for steam in the structural work machines. The machines are sized for rivets up to ¾ in., 1 in. and 1¼ in., and the reaches from 6 in. to 70 in.; the hammer riveter is adapted for rivets up to 1¼ in. and reaches of 48 in., 72 in. and 84 in. For all machines each part is separately illustrated and numbered, so that any replacement part can be ordered concisely and accurately.

Laundry Machinery.—A system for drying clothes is explained and illustrated in a catalogue issued by Messrs. Keith, Blackman and Co., Limited, whose head office is at 27, Farringdon Avenue, London, E.C. The drying medium is a current of hot air, generated by a fan, passing through a nest of heaters and kept in motion till it carries away the steam or moist air. The drying cabinet or room is designed to economise the heat and to give the steady regular output required in laundry work. All the details, including an ingenious way of gripping and releasing the linen, are carefully worked out. For large laundries a travelling clothes horse is shown, and for small places two cabinets are worked alternately and continuously, the hot current being switched from one to the other. A traveller machine dries over 450 bath towels per hour.

The Curing of Cacao.—Messrs. William McKinnon and Co., Limited, of Spring Garden Ironworks, Aberdeen, have sent us a most interesting catalogue of cacao-curing machinery. The fruit of the cacao tree was brought to Europe by Columbus, and became known first as chocolate, and afterwards as cocoa. Chocolate had a great vogue in this country at one time, but it was displaced by coffee, and then followed by cocoa, of which immense quantities are now sold. Cacao was prepared for export for hundreds of years by hand processes, and even now these are still used in many places. Labour is generally cheap, and if fine weather could be ensured the result would be fairly satisfactory. But the cacao is a delicate product, and its value is much reduced by adverse weather during the harvest. First the nibs have to be rubbed to clean them from mucilaginous and gummy matters, to be fermented for several days within narrow limits of temperature, and to be dried. The average loss in weight in drying is 56 per cent., and the total loss, bearing in mind that the fermenting operation means a loss of 14 per cent., is 62.5 per cent. The percentage of marketable cacao produced from the pod is, therefore, 37.5 per cent. Messrs. McKinnon construct machines by which all the above processes can be carried out indoors quite independently of the weather and of skill on the part of the operatives. These machines are of various sizes, to suit small or large plantations, and there are modifications of the same machine to suit other variations in crops and local circumstances. The desirability of having the various processes under direct control seems to be evident, while the capital outlay cannot be great when compared with the value of the crop. If it were possible to dry grain and hay indoors in this country in a few hours farming would be a more attractive occupation.

JOHN FRITZ MEDAL PRESENTED TO DR. H. M. HOWE.—We very much regret that owing to a printer's error the name of Dr. Henry Marion Howe, the eminent American scientist, was incorrectly spelt on page 102 of our last issue.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

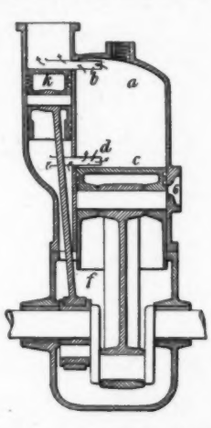
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

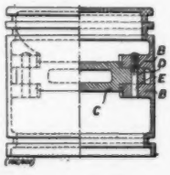
GAS ENGINES, PRODUCERS, HOLDERS, &c.

106,450. E. Tilston, London. Two-Stroke Cycle Engines. (1 *Fig.*) March 16, 1916.—This invention relates to improvements in two-stroke cycle internal-combustion engines of the crank-case compression type. According to the invention, the admission of carburetted air from the crank-case *f* to the cylinder *a* is effected by the piston *c* overrunning a port *d* suitably situated in the lower part of the cylinder in known manner, while the exhaust port *b* at the upper end of the cylinder is controlled



by a piston valve *k*, the under side of which is in communication with the crank-case *f*, so that the combined displacement of the piston *c* and piston valve is available for forcing the carburetted air into the cylinder, whereby good scavenging and charging are ensured. The carburetted air is preferably admitted to the crank-case by a port 6, overrun by the piston *c* as it approaches the end of the compression stroke, but an automatic check valve of usual form may be adapted. (*Accepted May* 30, 1917.)

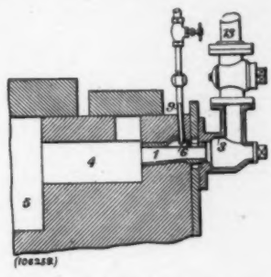
106,401. J. Buchanan, Stoke, Coventry. Pistons. (6 *Figs.*) September 23, 1916.—According to this invention, the piston is provided with pairs of internal ledges B projecting in planes normal to the axis of the piston, and a gudgeon pin C with flattened ends which engage between the ledges and are connected thereto. The gudgeon pin is inserted from the bottom of the piston upwards and then twisted through the necessary angle around the axis of the piston so that the flattened ends of the pin lie between the ledges B. When in position, the flattened



ends are connected between the ledges by split pins or by screws E. The piston can be provided with internal longitudinal grooves, and a circular groove between the ledges, so that the gudgeon pin can be guided upwards in the longitudinal grooves and then twisted into position in the circular groove. This invention enables the gudgeon pin to be attached to the piston shell without it being necessary to form any holes in the shell, and, further, there are no large bodies of metal to cause serious trouble through unequal expansion. (*Accepted May* 30, 1917.)

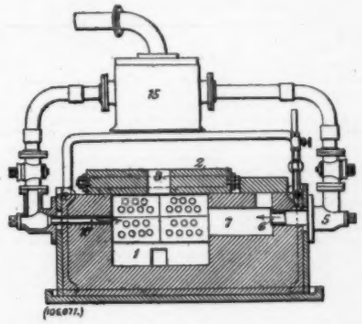
MINING, METALLURGY AND METAL WORKING.

106,259. F. W. Cotterill, Limited, and G. R. West, Darlaston, and J. Spencer, Walsall. Liquid Fuel Furnaces. (2 *Figs.*) May 22, 1916.—This invention has reference to liquid fuel burners for liquid fuel furnaces. According to this invention, the body part 3 of the hydrocarbon burner has a nozzle 1 of comparatively large bore, through which the hot blast from the hot-blast supply pipe 13 passes, flowing out through the front end into the combustion chamber 4, which communicates with the heating chamber 5 of the furnace. An oil pipe 9 supplies preheated oil in spray or jet form to the burner, and is arranged transversely to the direction of the flow of the hot blast through the nozzle 1, and terminates in an oil nozzle arranged at the top, or at one side of, the burner nozzle 1, and preferably at right angles thereto, as shown. This oil-feed nozzle 6 is set back some little distance in a side cavity or enlargement of the burner wall so as to prevent any possibility of the oil-feed nozzle being struck or touched by a cleaning bar when inserted in the nozzle from the back end, for the purpose of clearing away any slight deposit on the burner nozzle. As the hot blast flows through the burner nozzle 1, the preheated oil drips or is sprayed transversely into the hot blast through the oil nozzle 6, and is thereby immediately



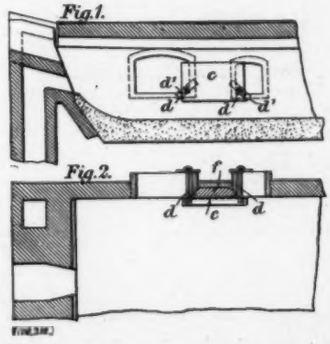
vaporised, and burns in the combustion chamber or furnace, and, owing to the fact that the outlet oil nozzle 6 is in the path of the on-rushing hot air, there is, when the furnace is working, an entire absence of deposit in the oil nozzle 6. (*Accepted May* 23, 1917.)

106,077. F. W. Cotterill, Limited, and G. R. West, Darlaston, and J. Spencer, Walsall. Liquid Fuel Furnaces. (3 *Figs.*) May 22, 1916.—This invention has reference to liquid fuel furnaces used for heating iron and steel bars in the manufacture of nuts and bolts, or for making drop-stampings or forgings. According to this invention, an auxiliary hot air-blast is provided and is delivered to the heating chamber opposite to the opening from the liquid fuel burner, this auxiliary hot-air blast being directed against the burning gases from the burner, and thus supplying hot secondary air to those gases, so that thorough and proper combustion ensues, and, moreover, by regulating this hot secondary air blast, the flames in the heating chamber can be controlled and the heat evenly distributed therein instead of, as has heretofore often been the case, the heating chamber being heated more at one part than another. The furnace proper is built as an open-topped



heating chamber 1, closed by the slab 2, in which is the waste heat outlet 3, the side walls of the heating chamber being built of the usual perforated bricks for the admission of the bars to be heated. The blast elbow fitting 5 and burner nozzle 6 are fixed at one end of the furnace, with the nozzle 6 projecting into the brickwork of the same, and arranged between this burner nozzle 6 and the heating chamber 1 there is a small combustion chamber 7, in which partial combustion of the gases takes place before entering the heating chamber 1. The auxiliary hot-air blast is supplied through blast-pipe 10, arranged and fixed in the end of the furnace immediately opposite the burner nozzle 6, and is connected to the blast-heating chamber 15, the said chamber 15 being heated by the waste heat from the heating chamber through the top outlet 3. The heating chamber 15 supplies the necessary blast to the burner nozzle 6. (*Accepted May* 16, 1917.)

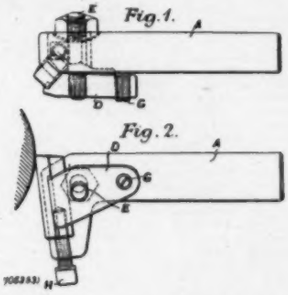
106,376. The Clyde Furnace Company (A), Limited, and W. Dixon, Glasgow. Open-Hearth Regenerative Furnaces. (3 *Figs.*) August 17, 1916.—The object of the invention is to provide an improved method of repairing, whilst the furnace is working, burned-out cavities. The invention consists in first



fitting or erecting at the burned-out part means capable of supporting or retaining the plastic refractory material in position in the cavity and then filling-in the required quantity of plastic or semi-liquid refractory material at the back of the retaining means, which latter is of such a nature as to stand, under action of the hot gases, for a sufficient length of time to allow of the refractory material solidifying before it is burnt away. The supporting or retaining means consists preferably of a plate of metal, or slab of fireclay, or other suitable refractory material *c*, and in the case of furnace linings the plate or slab can be inserted through the furnace door or otherwise and be arranged to cover the front of the cavity, the plate or slab being secured in place by means of bolts *d* and metal strips *d*1. When the plate has been secured, the repairing material is put in by means of a shovel, or otherwise, until a practically vertical wall of plastic material *f* is formed, the material retaining its position, as it is held in place by means of the retaining plate *c*, and this it does while the heat is on the furnace and until the plate is burned away, by which time the plastic material has become solid and approaches the strength of the original brickwork, while it also serves to support the upper walls and prevent their collapse. To enable the cavity to be readily and wholly filled up and joined to the material above, the patentees prefer to use a retaining plate which, at its upper end, bends away from the wall and thereby forms a kind of hopper, which facilitates the insertion of the plastic or semi-liquid material into the cavity. When the retaining means consists of a metal plate or refractory slab, the same, as it burns away, acts as a flux and causes the surface of the plastic material to take on a close and hardened surface. (*Accepted May* 30, 1917.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

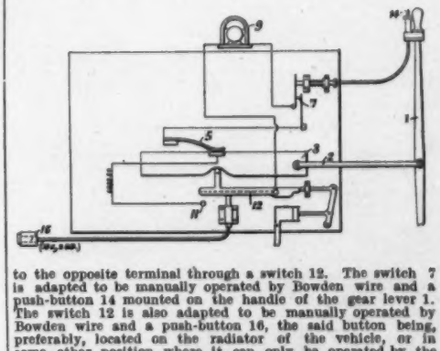
106,253. A. Herbert, Dunley Manor, near Whitchurch, and A. H. Lloyd, Earlsdon, Coventry. Tool Holders. (3 *Figs.*) February 19, 1917.—This invention relates to holders for tools for cutting metal, and comprises the combination of two grooved clamping members adapted to grip the tool, an adjusting screw to vary the distance between the members, and a clamping screw located between the tool and the adjusting screw. Such a holder can accommodate tools of very different sections, owing to the provision of the adjusting screw, which enables the



two clamping members to be maintained parallel to each other. The main body A of the tool-holder has a V-shaped groove at one end, and is held up to the main body A by a stud E. The member D has a V-shaped groove parallel with that in the main body, to engage the tool. An adjusting screw G enables the member D and the main body to be maintained parallel to each other so that tools of various sizes can be clamped satisfactorily. A screw H is provided under the tool in the main body for the purpose of supporting and adjusting the height of the tool. (*Accepted May* 23, 1917.)

MOTOR ROAD VEHICLES.

106,209. J. V. Ramsden, London. Motor-Propelled Vehicles. (3 *Figs.*) August 31, 1916.—It frequently happens that a careless driver of a motor-propelled vehicle will allow the engine to run while the vehicle is at rest with the gear lever in its neutral position. With a view to preventing this wasteful consumption of fuel, the invention, in its broadest aspect, may be said to consist in the provision of means whereby, when a motor-propelled vehicle is brought to rest and the change-speed or gear lever is in its neutral position, the ignition system is automatically interrupted, thereby stopping the engine, means under manual control being provided for re-establishing the ignition circuit to restart the engine. The gear lever 1 of the vehicle is connected by the link 2 to a slidably-mounted bar 3 of insulating material having a contact plate adapted, in the position of the parts shown, to make electrical contact with the brush 5, connected through a switch 7, to one terminal of the magneto-electric machine 9. The contact plate on the bar 3 is connected



to the opposite terminal through a switch 12. The switch 7 is adapted to be manually operated by Bowden wire and a push-button 14 mounted on the handle of the gear lever 1. The switch 12 is also adapted to be manually operated by Bowden wire and a push-button 16, the said button being, preferably, located on the radiator of the vehicle, or in some other position where it can only be operated by the driver first vacating his seat. It will be apparent that if the vehicle is at rest and the gear lever 1 in the neutral position, the switch 12 will rest upon a contact point 11, thereby short-circuiting the magneto current and stopping the engine, and it is necessary for the driver to leave his seat to operate the push-button 16, thereby opening switch 12, before the engine can be started again. It may, in some cases, be necessary that the driver should allow the engine to run whilst the vehicle is at rest, and for this purpose the push-button 14 is provided, thereby interrupting the circuit at switch 7 and allowing the engine to run. (*Accepted May* 23, 1917.)

105,999. H. E. Buck, Swinton, Manchester. Chassis Construction. (5 *Figs.*) May 15, 1916.—According to the invention, the chassis is divided into two parts 1, 2, the adjacent ends of the load-carrying and motor-carrying parts being supported upon a common axle 4, upon which are mounted the tractor wheels 5. Rigidly connected to the axle 4 are two sets of stay bars 6, 6, and 7, 7, constituting a rigid under-frame with

Fig. 1.

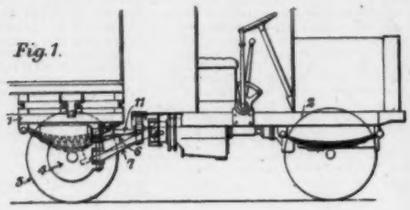
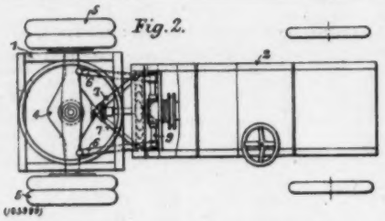
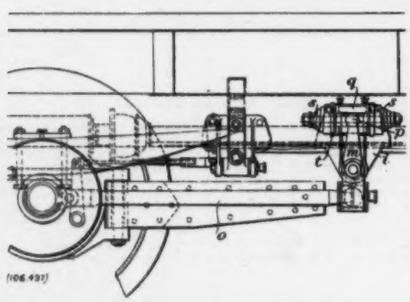


Fig. 2.



said axle. Across the bars 7, 7 is arranged a transverse spring, the apex of which supports the rear end of the motor frame 2. Journalled in the ends of the bars 6, 6 is a cross-bar 9, the centre of which is formed with a collar through which passes the cardan shaft 11, having a universal joint 12, whose centre of movement coincides substantially with the point of intersection of the axial and transverse centres of the cross-bar 9. (*Accepted May* 16, 1917.)

106,437. The Birmingham and Midland Counties Transport Company, Limited, and G. E. D. Rails, Birmingham. Spring Mountings. (3 *Figs.*) May 24, 1916.—This invention relates to spring mountings for motor vehicles of the type in which the wheels, which are coupled to the chassis by spring suspension means, are furnished with rods extending longitudinally of the chassis and coupled to the latter by means which permit of a longitudinal movement of such rods against the resistance of suitable resilient media. According to the present invention, the rods *o*, which extend longitudinally of the chassis, are coupled to the latter by mechanism comprising or involving a pivotally-rocking lever *m*, which co-operates with a plurality of resilient elements incorporated in opposed relationship with each other. The lever *m* is, at its upper extremity, bifurcated to accommodate



a rod *p* adapted to slide or move longitudinally in a hollow boss-like part *q* of the bracket *t*. Both extremities of the rod *p* pass axially out of the hollow boss-like part *q* and carry at their extreme ends nuts, in relation to which the minor extremities of spiral springs *s* operate. The major extremity of each spring *s* operates in relation to a plate or cup *t* which is provided upon a sleeve encircling the rod *p*, one of these sleeves being disposed on each side of the bifurcated upper extremity of the lever *m*, so that the springs *s*, *s* are thereby enabled, through the medium of the rod *p* and members *t*, to control the rocking movement of the member *m*. (*Accepted May* 30, 1917.)

RAILWAYS AND TRAMWAYS.

106,240. A.B.C. Coupler, Limited, Westminster, and V. J. H. Webb, Bradmore, Wolverhampton. Buffers. (8 *Figs.*) December 28, 1916.—This invention is connected with the buffers of railway vehicles. The invention relates to the means by which the buffer plunger is retained in its casing, and

Fig. 1.

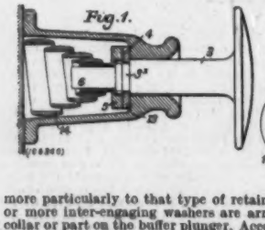
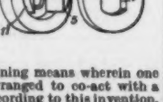


Fig. 2.

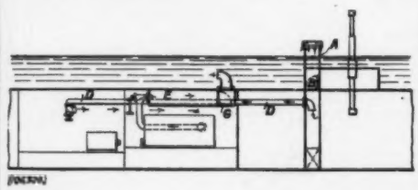
Fig. 3. *Fig. 4.*



more particularly to that type of retaining means wherein one or more inter-engaging washers are arranged to co-act with a collar or part on the buffer plunger. According to this invention, the washer adapted, when in use, to be located in the recess formed between the enlarged outer end of the plunger and the elongated collar is formed flat, and the co-acting washer is formed cup-shaped with projections adapted to enter and fill the slots in the flat disc and to abut against the enlarged end of the plunger, the depth of the recess in the cup-shaped washer being such that a small space is left between the face of the collar and the bottom of the recess. The buffer plunger 3 has a short portion 6 of reduced diameter supported in the inner coil of the volute spring 14, an annular groove 7, and a collar 8 furnished with flat faces 9. The flat washer 4 adapted to fit in the groove 7 is, as shown in Fig. 4, furnished with an aperture 10 of the same shape and size as the collar 8 on the plunger, so that it may slide over the said part into the groove 7, in which it is given a half-turn so that the flats 4*x* on the washer are at right angles to the flats 9 on the collar 8. With the flat washer in this position, the cup-shaped locking washer 5, Fig. 3, is slipped over the part 6 of the plunger, the projections 11 formed thereon being held in such a position that they will enter the spaces existing between the rounded surface of the plunger and the ends of the aperture 10 in the flat washer, the outer end of such projection abutting against the face 3*x* of the plunger 3. When the parts are in position in the casing 1, the face of the flat washer 4 bears against a shoulder 13 formed on the interior of the casing 1, and the locking washer is maintained in position by means of the volute spring 14, the inner coil of which is adapted to act as a guide and support for the part 6 of the plunger. (*Accepted May* 23, 1917.)

SHIPS AND NAUTICAL APPLIANCES.

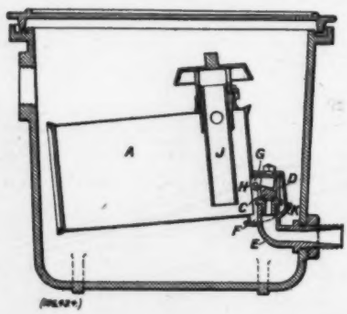
106,330. Scott's Shipbuilding and Engineering Company, Limited, and J. Richardson, Greenock. Submarine or Submersible Boats. (2 *Figs.*) May 19, 1916.—This invention relates to submarines or submersible boats of the type equipped with means for admitting air to the engine-room and allowing the exhaust gases to pass off when the boat is submerged to such an extent that the periscope is above the surface while the conning tower may be submerged; the means for admitting air consisting of an air inlet connection A, auxiliary to the usual air



inlet, with the air admission opening above the top of the conning tower and fitted with a valve B adapted to be closed automatically, the inner end either being fitted with pipes D leading to different parts of the vessel or discharged into the machinery space at a point remote from the air intake to the heat engines, the exhaust expelling means including a reservoir E for the exhaust products, with a valve G controlling the discharge and arranged to open when the pressure in the reservoir exceeds the pressure due to the head of the water. (*Accepted May* 30, 1917.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

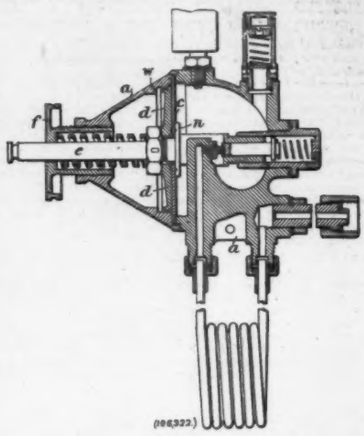
106,424. H. L. Butterworth, Swinton, and Lancaster and Tonge, Limited, Pendleton, Manchester. Steam Traps. (3 *Figs.*) November 22, 1916.—The invention relates to the type of trap in which a valve is controlled by a float in such a manner that the water, after passing the valve, passes through the float and into the box or vessel containing the latter. It is now proposed to carry the valve C and seating D on the upper end of an L-shaped pipe or bend E which forms the inlet to the trap, the lower or horizontal end of the pipe being bolted or otherwise secured to the end of the box or vessel containing the float. The float A is preferably cylindrical, and has a hole F in the underside at one end large enough to admit the valve and seating and the upper end of the pipe supporting them. The valve is operated by a hinged lever G attached to the seating and also to the end of the float in such a manner that the latter,



whilst fixed to the lever at one end, is free to fall at the other so as to open the valve, or rise so as close it. Owing to the valve being located inside the float, it discharges directly into it. A down tube J, or similar apparatus, is fitted to the float to allow the water to escape from it, while trapping the vapour which occupies the upper part of the float and causes it to rise when the water has sufficiently escaped. To prevent the water escaping except to a small extent through the hole F, the corner of the float is rounded off to a radius taken from the pivot H of the hinged lever G and a flange K is formed or fastened on the pipe E to fit the curved corner, so as to leave a space between it and the corner of the float of not more than one-sixteenth of an inch. (*Accepted May* 30, 1917.)

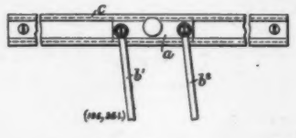
MISCELLANEOUS.

106,322. J. Chignell, Acocks Green, Birmingham, and The Farringdon Works and H. Pontifex and Sons, Limited, London. Pressure-Reducing Valves. (3 *Figs.*) May 17, 1916.—The invention relates to pressure-reducing valves. A reducing valve, according to this invention, comprises a casing *a* made in halves, a diaphragm *c* held at its edge between the faces of said halves and clamped centrally between a flange *n* on the supporting spindle *e* and a piston *d* of large area, said piston acting as an axial guide and support within the casing in a recess *w* in which it can slide. The means of supporting the diaphragm *c* centrally comprise the central spindle *e* secured to the diaphragm



and a bearing in the outer end of each half of the casing, one of the said bearings *f* being axially movable within the casing to adjust a spring between itself and the diaphragm whilst the spindle projects from one end of the adjustable bearing for testing purposes. (*Accepted May* 30, 1917.)

106,251. C. H. Thompson, Bournville, Birmingham, and W. Mavitta, Aston, Birmingham. Drafting Machines. (5 *Figs.*) January 29, 1917.—This invention has reference to drafting machines of the type in which a drawing square and protractor are combined in a single angularly-adjustable unit that is pivotally mounted in a protractor housing carried by a parallel-motion link arrangement adapted to be mounted upon or anchored to a drawing board. It is proposed, according to this invention, to use, as a mounting or support for an adjustable slide, a long or extended guide or runner which is adapted to be directly secured to the upper part of a drafting table and parallel with the longer edges thereof, so that by moving the slide along the said guide or runner the machine can be shifted to any



part of the table or board where it may be required for use. Each of the slides *a* on which the parallelogram arms *b*1, *b*2 are pivoted is mounted in, and is longitudinally adjustable within, an attachment consisting of a channelled or dovetailed sectioned strip or bar *c* of metal or other suitable material, which is fixed to the face of the upper part of the drawing table, parallel with the longer edges thereof, and is of such a length as will provide for an extensive range of adjustment of the machine relative to its attachment, so that the square and protractor unit can be shifted or transported to, and used upon, any part of a long drawing; the extent of such range being limited only by the length of the guide or runner attachment wherein the slide is mounted. (*Accepted May* 23, 1917.)

CANADIAN RAILWAYS.—We read in *The Iron Age* that the Imperial Munitions Board of Canada has confirmed the statement that it has authorised the Algoma Steel Corporation and the Dominion Iron and Steel Company to roll 50,000 tons of standard section rails. The Board does not state what is to be done with these rails, but it is believed they will be distributed among Canadian railways, which helped the Dominion Government last year by taking up rails which were in track and shipping them across the Atlantic for use in the war zone. These railways were unable to receive new rails from mills in the United States.

TIN-MINING IN BRITISH MALAYA.—Last year was a profitable one for tin miners in the Federated Malay States. Although the output was 2,896 tons less than in 1915, higher prices ruled throughout the year, and the total value of the 43,870 tons exported amounted to 7,526,566*l.*, against 7,164,968*l.* for 46,766 tons in 1915. The average price on the local market was equivalent to 171*l.* 11*s.* 2.1*d.* in 1916, against 153*l.* 4*s.* 3.1*d.* in 1915; on the London market the lowest price was 161*l.* 10*s.* per ton and the highest 205*l.*, the average being 182*l.* 3*s.* 5*d.* per ton. In his yearly review of mining in the Federated Malay States the senior warden of mines (Mr. W. Eyre Kenny, M.Inst.C.E.) gives the following comparative table of output and value of tin in the four States:—

	1915. Tons.	1915. £	1916. Tons.	1916. £
Perak	27,776	4,255,603	27,242	4,675,379
Selangor	13,938	2,135,236	12,241	2,099,072
Negri Sembilan ..	1,244	189,699	907	155,887
Pahang	3,808	584,430	3,480	596,228
	46,766	7,164,968	43,870	7,526,566

Shipping and other charges showed an increase in 1915.